A Case Study of Business Intelligence Applications for Business Users

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ABSTRACT

This research is conducted in two parts, with the first part reviewing the standard industry approach to providing organisations with business intelligence (BI) architecture. The discussion begins with a brief history of the evolution of data warehouses and business intelligence (DW/BI) systems. The generic approach to developing a DW/BI is described and the interfaces and features of BI applications are explored as to how they support the various user roles within an organisation e.g. executive, business user and business analyst. The discussion is presented using references to the Zachman Framework.

The second part of the research focuses on a case study examining an organisation's implementation of a bespoke BI solution which is supporting its business managers with decision support, reporting and analysis. Where today's business intelligence is about giving business users the tools to get the information they need out of the data warehouse and thus reducing the reliance on IT departments, the bespoke solution studied puts the reliance on IT staff to support their business intelligence requirements.

The BI requirements are compared and contrasted against the features of third party BI tools to reach a conclusion as to whether they support the reporting needs of the planning group in the case study or whether their needs are so specific that a bespoke solution is the best option and thus reliance on IT departments is still necessary to support the delivery of business intelligence.

The findings from the first part of the research are the view that for the successful development of BI applications the BI user's needs should be addressed from the requirements stage, and the development of BI applications should run as a parallel activity alongside the data warehouse development activities. The BI applications should be developed by BI developers who have knowledge of the business, rather than technical IT staff. This view is supported by leading DW/BI authors such Kimball *et al.* (2008). The research also found the needs of the BI application users can be analysed by grouping them into one of five classifications of user – Tourists, Farmers, Explorers, Miners and Operators and that different user interfaces are needed to support their needs.

The case study in the second part of the research found that the implementation of the DW/BI system in SAP using SAP BEx software fails to provide planning staff with BI applications that meet with all their reporting and analysis needs and has therefore led to the development

of bespoke applications. The findings suggest that this may be because the planning staff were not involved at the scoping and planning stage of developing the DW/BI.

The investigations found that most of the features in the bespoke BI system could be developed using a third party solution and that they are available in the SAP family of products. The level of expertise needed to develop the features ranged from easy to technical. The adoption of a third party tool could be used to develop the reports by the BI application developers identified by Kimball *et al.* (2008) and provide the planning managers with an intuitive and flexible user interface that can be easily customised and maintained. It was also found that SAP BusinessObject's Crystal Reports provide a rich user interface that is easy to use to support most of the BI features.

DISCLAIMER

This work is original and has not been previously submitted in support of any other qualification.

Signed: _____

Date: _____

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1.1. Overview

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1.2. Research Objectives

1. To review the standard approach to developing a DW/BI system.
2. To understand the user's needs of a BI application and what a BI application is.
3. To carry out a case study of a bespoke BI application and compare and contrast its features against third party solutions.
4. To make a recommendation to the organisation based on the research findings.

1.3. Literature Search

A comprehensive literature search was carried out at the onset of the research and continued throughout the duration. The survey included a search on journals, library

books, electronic books, articles and the web. Books and articles by leading data warehouse authors, such as Ralph Kimball, William Inmon and Joy Mundy; and papers by John Zachman and J. Sowa have been referenced in the first part of this report. Although there is no similar case study to the one carried out in Part Two, the starting point was a paper published by SAP, describing a data warehousing project for the consumer brands organisation, Unilever, who used SAP's Business Objects Data Integrator to develop their data warehouse.

1.4. Structure of the Report

Part One of the report begins with a review of the evolution of DW/BI systems in Chapter 2. The Zachman Framework and the Kimball Lifecycle are two approaches to designing an information system and these are described in Chapter's 3 and 4. Chapter 5 describes a generic approach to developing a DW/BI system by combining the two approaches to designing a system described in the previous two chapters.

Having discussed the generic approach to developing a DW/BI, Chapter 6 introduces the users of the BI applications and Chapter 7 discusses the needs of the BI users by using the Zachman Framework to present the discussion. The BI interfaces that support the needs of the BI users are discussed in Chapter 8. Part One concludes with a summary of the discussion.

The case study in Part Two, begins in Chapter 10 with a description of the implementation of a SAP business warehouse and bespoke BI application. The BI requirements for a third party solution are analysed in Chapter 11 and the testing environment for investigating the third party software is described in Chapter 12. Chapter 13 is a description of the investigations carried out. A discussion of the findings from the case study is presented in Chapter 14.

The report concludes with a discussion and conclusion in Chapter 15 and with recommendations based on the research findings in Chapter 16.

PART ONE

2. BACKGROUND OF DATA WAREHOUSING AND BUSINESS INTELLIGENCE

Relational databases of the 1980s and early decision support systems of the 1960s underpin the evolution of DW/BI systems over the past fifteen years. Accompanied with advances in information technology, such as the increase in disk storage capacity, and the shift from mainframe computers to PC-based client/server computing meant that organisations were developing operational systems to automate their business processes. Furthermore, the emergence of the internet in the 1990s and the increase in online systems meant an increase in the volume of data being stored.

Many organisations also found themselves with disparate systems and this was partly due to the organisational structure. According to Benyon-Davies (2002, p. 231) often organisation's information systems are developed within the existing organisational structure, e.g. the marketing department will have its own information system and the production department will have its own production information system.

Information systems were solely in the domain of the IT professionals, but as software packages became more sophisticated, they could be used by non-IT people and so there was a shift to them being used by business users such as managers or financial staff to get access to the organisation's information systems.

These changes caused huge problems for delivering information to managers and other users. In fact, according to Hoffer, Prescot and McFadden (2007, p. 421), despite having mountains of data, and often many databases, few organisations had more than a fraction of the information they needed. They go on to say that modern organisations are said to be drowning in data but starving of information.

A key discovery that led to the development of data warehousing was the separation of operational and informational systems. An operational system is one that is used to run the business in real time, based on current data. They handle the day-to-day transactions of the organisation, e.g. the processing of orders or the handling of patient records. In contrast, an informational system is one that is designed to support decision-making based on historical snapshot-in-time and prediction data (Hoffer *et al.* 2007, p246). Figure 1 shows a comparison of the key differences between operational and informational systems. Of note are the

different users of the systems. The operational systems are used by clerks, salespersons and administrators who process the transactions; and the informational systems are used by managers, business analysts and customers who are interested in what the information can tell them about the business and to support decisions.

Characteristic	*Operational Systems*	*Informational Systems*
Primary purpose	Run the business on a current basis	Support managerial decision making
Type of data	Current representation of state of the business	Historical point-in-time (snapshots) and predictions
Primary users	Clerks, salespersons, administrators	Managers, business analysts, customers
Scope of usage	Narrow, planned, and simple updates and queries	Broad, ad hoc, complex queries and analysis
Design goal	Performance: throughput, availability	Ease of flexible access and use
Volume	Many, constant updates and queries on one or a few table rows	Periodic batch updates and queries requiring many or all rows

Figure 1 - Comparison of Operational and Informational Systems (Hoffer *et al.* 2007, p. 246)

With a need to consolidate data from fragmented operational systems into a single company-wide view of the data, and the distinction made between operational and informational systems, the data warehouse was born. In 1988, Devlin and Murphy published the first article describing the architecture of a data warehouse. Then in 1992, Inmon published the first book describing data warehousing and has subsequently become one of the most prolific authors in this field (Hoffer *et al.* 2007, p.423).

The data warehouse was developed to be a store of enterprise data that has been extracted from disparate operational systems, cleaned and transformed into a non-updatable, subject-orientated collection of data designed to facilitate management decision making.

The last decade has seen data warehousing reach full maturity and acceptance across the business world (Kimball, Ross, Thornthwaite, Mundy, Becker. 2008). The business user has realised the value of high quality data and a term which reflects this is *Business Intelligence*.

Mundy, Thornthwaite and Kimball (2006, p. pxxv) suggest data warehousing and BI are fundamentally about providing business people with the information and tools they need to make both operational and strategic business decisions. The business people are the executives, managers and analysts and they are the people in an organisation who can make

decisions that affect the success of the business. According to Imhoff and Pettit (2003, p. 4) the business users need the ability to study past behaviours and actions in order to understand where the organisation has been, determine its current situation, and predict or change what will happen in the future.

It is useful at this stage to define the terms 'data warehouse' and 'business intelligence'. According to Kimball *et al.* (2008, p. 10) some refer to data warehousing as the overall umbrella term, with the data warehouse databases and BI layers as subset deliverables within that context. Alternatively, others refer to BI as the overarching term, with the data warehouse relegated to describe the central data store foundation of the overall BI environment (Kimball *et al.* 2008, p10). This dissertation uses Kimball's term DW/BI to refer to the complete end to end system and when discussing individual components, the data warehouse will be referred to as the enterprise data warehouse (EDW) and the reporting and analytical applications will be referred to as BI applications.

Figure 2 shows a complete DW/BI system. The data is extracted from the source systems into a data staging area. The data is cleansed, transformed and loaded into the EDW and data marts and is fed to the end user presentation tools.

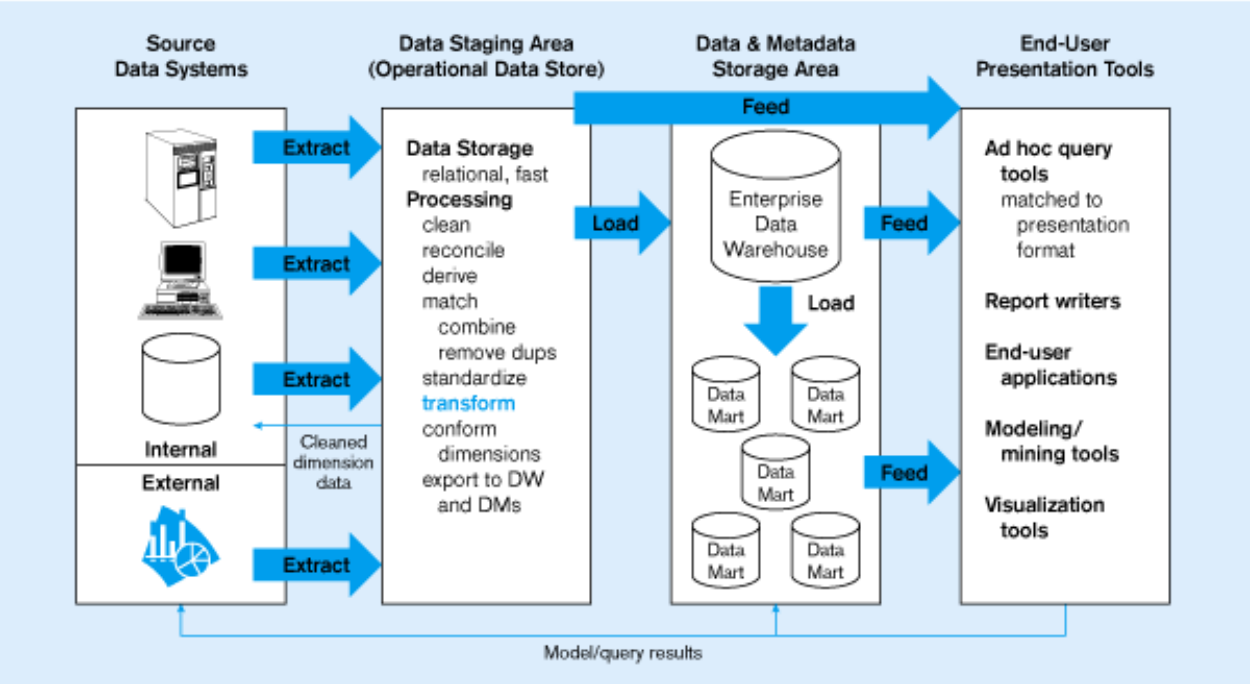


Figure 2 – Complete DW/BI System. Source: Hoffer *et al.* (2007, p. 431)

To complete the history of DW/BI a new buzzword is emerging - 'Business intelligence 2.0' - to refer to the instant access that decision makers have to data by dynamic querying of real-time corporate data, and a more web- and browser-based approach to such data, as opposed to the static reports and proprietary querying tools that had characterised previous BI software. The goal of BI 2.0 is not to store data in a database but to use event-stream processing in order to cut time from when an event occurs and when action is taken.

Many of today's BI users only look at reports when they know something is amiss. However, harnessing the technical capability of BI 2.0 to offer a more agile and responsive system will deliver real-time, historical and external information on demand, and with a recognisable and intuitive interface that does not need to be learned. It also offers the facility to combine applications in a mash-up so that users can build bespoke programs that suit their individual needs. Overall this makes it easy to analyse information on a daily or even hourly basis, which offers ongoing insight into all operational business processes and flags up irregularities before they become an issue (BCS, 2009).

This brief history describing the continuing evolution of data warehousing and the shift in focus on the business users' needs in the form of business intelligence lays the foundations for the discussion in the next section, where the development of a DW/BI system is briefly described. It begins by introducing two approaches to developing an information system: the Zachman Framework and Kimball's DW/BI Lifecycle.

3. THE ZACHMAN FRAMEWORK

In an article in the IBM Systems Journal in 1987, John A Zachman presented a descriptive framework for defining and controlling the interfaces and the integration of all the components of a complex system. He used disciplines independent to information systems, such as buildings, airplanes or any other complex engineering product, and proposed that by using the analogy of how these complex systems are built, and relating it to information systems he could specify a framework for information systems architecture (ISA). The framework has become known as the Zachman Framework.

The Zachman Framework provides a way of viewing a system from different perspectives and showing how they are all related (Zachman, 1987). It was initially represented by a matrix of three columns: data, function and network, representing various aspects of the enterprise that can be described or modelled; and six rows representing the various perspectives from which

the aspects can be described. The perspectives of scope, business model, system model, technology model, detailed representations and the functioning enterprise viewpoint are aimed at the different roles involved in building a complex system e.g. planner, owner, designer, builder and subcontractor.

The cell at the intersection point of each row and column provide an isolated representation of the way someone views the product (that person's perspective) for a particular aspect of the product. This approach enables the business representative or developer to focus on a part in isolation, whilst also being able to see how it fits into the whole picture (Imhoff, Loftis & Geiger, 2001). Likewise, each row represents a complete view of the system from a single perspective e.g. from the designer's point of view; and each column provides a complete view of one aspect of the system e.g. all the data views for the planner, owner, designer, builder, subcontractor.

The framework was extended by Sowa and Zachman (1992) to include three further aspects: people, time and motivation. Thus the matrix now has 30 different perspectives consisting of six columns and five rows.

Zachman (1987) suggests that there are additional descriptions of the aspects that can be thought of as asking an English question; the data aspect addresses "what?"; the functional aspect addresses "how?"; the location aspect addresses the "where?"; the people aspect addresses "who?"; the time aspect addresses "when?" and motivation addresses "why?". Figure 3 shows the extended Zachman Framework diagram.

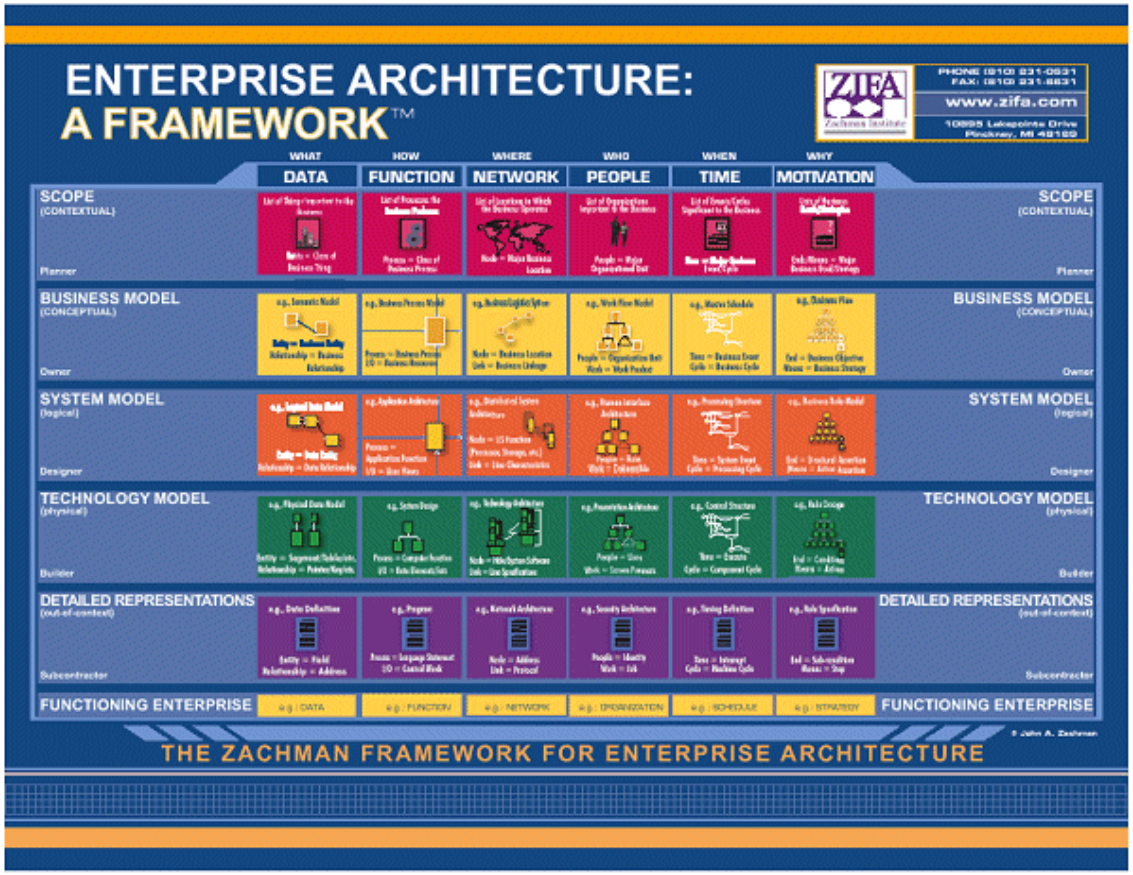


Figure 3 - Zachman Framework (Source: http://www.opengroup.org/architecture/togaf8-doc/arch/chap39.html)

Inmon (2005), an expert of DW/BI development advocates using the Zachman Framework to focus requirements on the enterprise as a whole and ensure that all aspects of the enterprise have been considered in the development of a system.

4. THE KIMBALL DW/BI LIFECYCLE

Ralph Kimball is a leading author in DW/BI design and his lifecycle approach to developing a DW/BI system is shown in Figure 4. Note how the business requirements definition stage informs the next stage which is split into three tracks: the technology track, data track and the BI application track. Also note how the BI application track runs in parallel to the other tracks and is fed by the business requirements, suggesting that the BI applications are equally as important as the technical architecture and the database design, and are addressed from the beginning of the lifecycle. Like the Zachman Framework, a complete DW/BI system can be developed using this lifecycle approach.

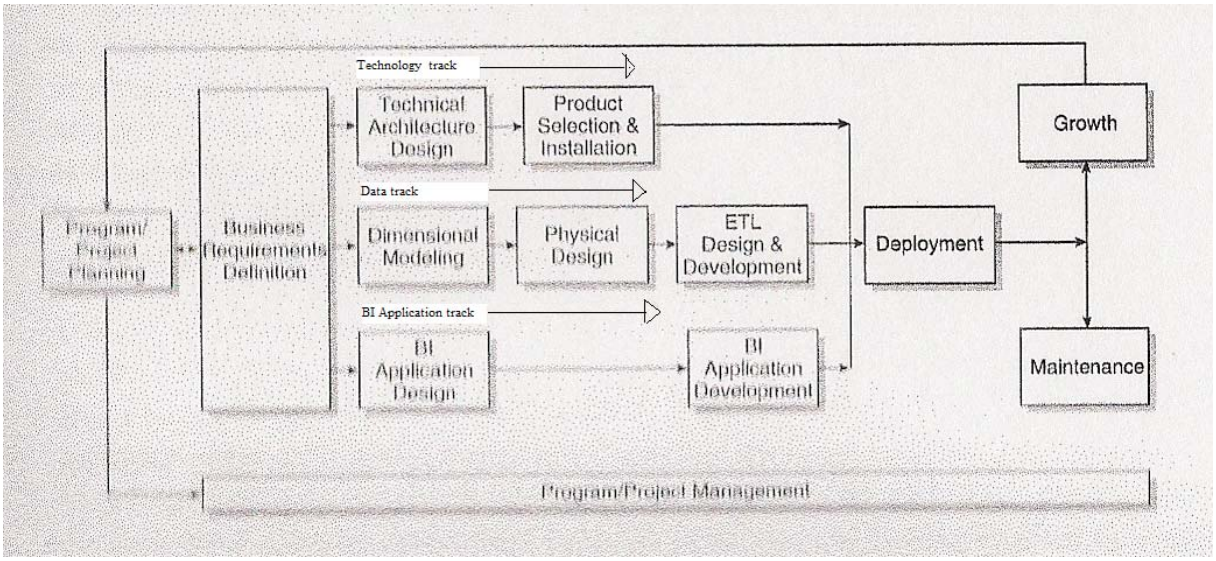


Figure 4 - The Kimball Lifecycle Diagram (adapted from Kimball *et al.* 2008, p. 3)

5. GENERIC DW/BI, THE ZACHMAN FRAMEWORK AND THE KIMBALL LIFECYCLE

By combining the Zachman Framework and the Kimball Lifecycle approach, the generic approach to developing a complete DW/BI can be taken and the Zachman Framework applied to the different perspectives. Kimball's BI application track can also be combined by splitting the 'How' column into 'back room' and 'front room'. These terms are used by Kimball *et al.* (2008, p. 110) where 'back room' is used to describe the data acquisition or Extract-Transform-Load (ETL) side of the architecture (the technology track in Kimball's lifecycle), and the term 'front room' for the presentation server side of the architecture (the BI Application track) where the query-able data is stored and BI applications and services sit.

Making this back room and front room distinction can also be applied to the staff involved in the development of the DW/BI. Where the back room staff consist of the data architects, data modellers, ETL developers and DBAs; and the front room staff are the BI architects, BI designers and BI developers.

The main difference between a BI application developer and a traditional IT developer is where the IT developer tends to work with programming languages and is likely to access data directly in the database, the BI application developer is likely to be using off-the-shelf

query and reporting software (Kimball *et al.* 2008, p. 37), and they will have a deep understanding of the business and the meta data.

This is not intended to be an exhaustive discussion on developing a DW/BI system, but presents an overview of the topics that are addressed when designing a system so that they can give some background to the discussion on the user's needs of BI applications which follows.

Table 1 is a representation of a DW/BI system within the modified Zachman Framework.

DIMENSIONS **PERSPECTIVES**	**WHAT** **DATA**	**HOW** **FUNCTION**		**WHERE** **NETWORK**	**WHO** **PEOPLE**	**WHEN** **TIME**	**WHY** **MOTIVATION**
		Back Room	**Front Room**				
SCOPE/DESCRIPTION **Ballpark view**	List of entities important to the business	List of processes the business performs	**Reporting needs and analytic themes**	List of locations in which the business operates	The organisation as a whole	Events significant to the business	Business goals and strategy
BUSINESS MODEL **CONCEPTUAL** **Owner's view**	Entities and relationships	Define major business processes	**Define reporting processes i.e. batch reports, web access, data mining**	Overall DW/BI architecture and infrastructure strategy	Data Architect, BI Architect	Data retention period, up-time requirements, expected performance	Define major objectives. Business areas to be analysed, reporting and adhoc query expectations
MODEL OF AN INFORMATION SYSTEM **Designer's view**	Dimensions	Dimensional Data Model Design of DW and Data Marts, design ETL process. Design OLAP	**BI applications design**	Data warehouse infrastructure and architecture	Data Modeller, ETL developer, BI designer	Granularity of data	Design the DW/BI
TECHNOLOGY MODEL **Builder's view**	Data tables	Physical data model for RDBMS. ETL process	**BI Applications development**	Third party BI software to support decision support, reporting and analysis tools. Bespoke applications	DBA, BI application developers	Granularity of data	Implementation of the design
DETAILED DESCRIPTION **Out of context or worker's**	Database description, meta data description	ETL loads into data warehouse and data	**BI applications installation**	Data warehouse installation and BI applications software	DBA, maintenance team	Schedule of data loads and system backups	Working system

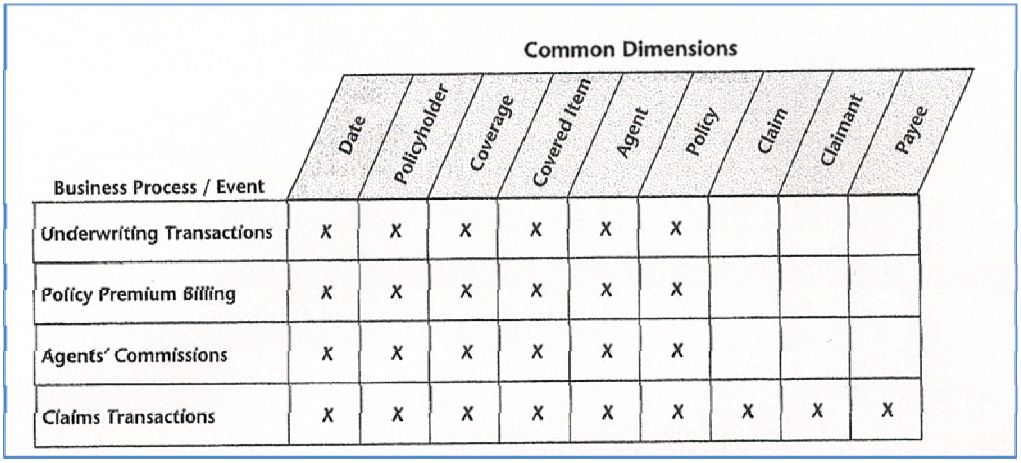
view		marts.		installation.			
FUNCTIONING ENTERPRISE	Data	Functions	Functions	Systems	Resources	Schedule	Goals

Table 1 - Zachman Framework for a Generic DW/BI System

5.1. Scope/description (Planner's View)

The first row of the framework in Table 1 is a view of a complete DW/BI system from the planner's perspective; this is a very high level overall view, and shows all the considerations that are made when planning a DW/BI. In Kimball's DW/BI lifecycle this is equivalent to collecting the requirements stage. It includes listing all the entities of importance to the business e.g. Customer, Product, Payment, so that they can be considered for inclusion in the system.

The back room includes identifying the business processes the business performs e.g. order processing, payment processing. Kimball *et al.* (2008, p. 90) suggests using a bus matrix diagram produced from gathering the requirements to describe the overall data architecture for the system (see Figure 5). The rows correspond to the business processes and the columns are the natural groupings of standardised reference data which Kimball refers to as conformed dimensions.



	Common Dimensions								
Business Process / Event	Date	Policyholder	Coverage	Covered Item	Agent	Policy	Claim	Claimant	Payee
Underwriting Transactions	X	X	X	X	X	X			
Policy Premium Billing	X	X	X	X	X	X			
Agents' Commissions	X	X	X	X	X	X			
Claims Transactions	X	X	X	X	X	X	X	X	X

Figure 5 - Sample High Level Enterprise Warehouse Bus Matrix (Kimball 2008, p. 90)

The front room addresses the reporting needs and analytical themes of its users. Kimball *et al.* (2008) support addressing the needs of the front end users at the planning/scoping stage. Figure 6 shows an example of how the analytical themes gathered from the requirements can be mapped to the business processes to ensure that they are considered for inclusion at the planning stage.

Analytic Theme	Inferred or Requested Analyses	Supporting Business Process	Comments
Sales Planning	- Reseller historical orders analyses	- orders	By customer, by territory, by sales region (from state)
	- Sales forecast	- orders	Forecast is a business process that uses orders data as an input
Sales Performance	- Orders by current territory	- orders	
	- Orders by original territory	- orders	
	- Sales rep performance report	- orders - forecast	Orders and forecast by sales rep
Sales Reporting	- Resellers ranked by orders in a given territory	- orders	
	- Churned customer list	- orders	Customers who have not ordered in X months
Price Lists	- Current price list	- orders	This is a connectivity issue, not a data warehouse issue
Special Offers	- Relevant customers by territory based on orders history	- orders	
	- Inventory status (out of stock)	- inventory	
Customer (Reseller) Satisfaction	- Calls by complaint type, product and customer attributes	- call tracking	
	- Order metrics of satisfaction	- orders	e.g. due date versus ship date
	- Returns by reseller by return reason	- returns	
International Support	- Local language translations of Product descriptions	- n/a (product dimension)	This is a transaction system problem. We need to make sure we can handle multiple languages in the DW/BI system, but the source system has to capture them when new products are created.

Figure 6 - Analytic Themes and Supporting Business Processes from the Interview Summary. Source: Mundy *et al.* (2006, p. 32)

5.2. Enterprise Model (Owner's View)

Having defined the scope of the DW/BI, the business model for the enterprise provides a conceptual view of the entities and their relationships from the owner's perspective. The owner is the recipient of the final product. In the first column, entities and relationships are addressed. Figure 7 shows an extract from an enterprise model diagram, the model captures the major categories of data (defined in the scope) and the relationships between data such as between a customer and his/her order.

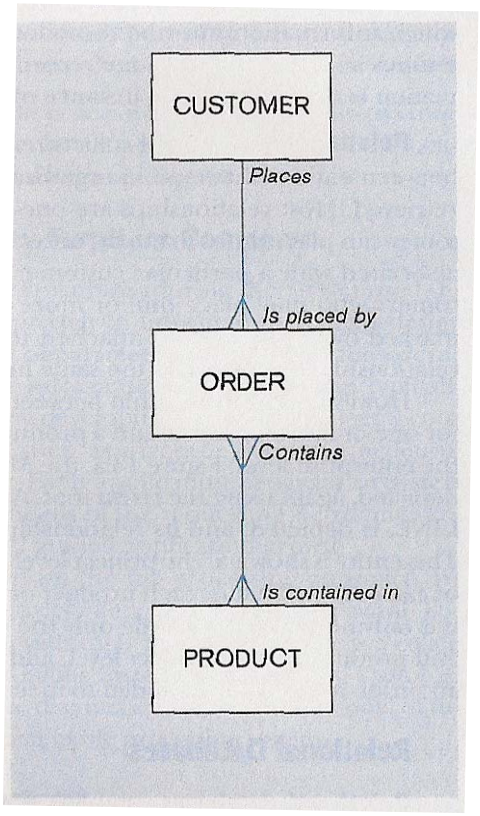


Figure 7 - Extract of an Enterprise Model Diagram. Source: Hoffer *et al.* (2007, p. 9)

The Entity-Relationship diagram is independent of any database design and the same diagram can be used to represent both traditional relational database models and dimensional models because they both represent the relationships between data entities. According to Kimball *et al.* (2008, p. 235-236), the major difference between the two modelling techniques is the level of normalisation. Relational models are designed to eliminate redundancy by dividing the data into many discrete entities and are more suited to operational systems because it makes transaction loading and updating simple and fast. Dimension models consist of a normalised fact table and de-normalised dimension tables with single part keys that connect directly to the fact table.

The second column for the back room is where the major business processes (e.g. payment processing, order processing) to be included in the system are defined, this may be in the form of a data flow diagram. Also, the source systems are identified. For the front room it includes defining the reporting processes i.e. batch reports, web access, data mining, to support the user community.

The third column describes a high-level overall view of the DW/BI system in the architecture plan. The technical architecture plan describes the flow of data from the

source systems to the decision makers and the transformations and data stores that data goes through along the way. It also specifies the tools, techniques, utilities, and platforms needed to make that flow happen (Kimball *et al.* 2008, p. 112). Figure 8 is an example of a high-level system architecture model. The back room architecture is identified on the left of the diagram.

The front room (identified on the right of Figure 8) architecture refers to the BI applications. It addresses what users need to get the information out in a usable form and what types of BI applications are needed to support the user community.

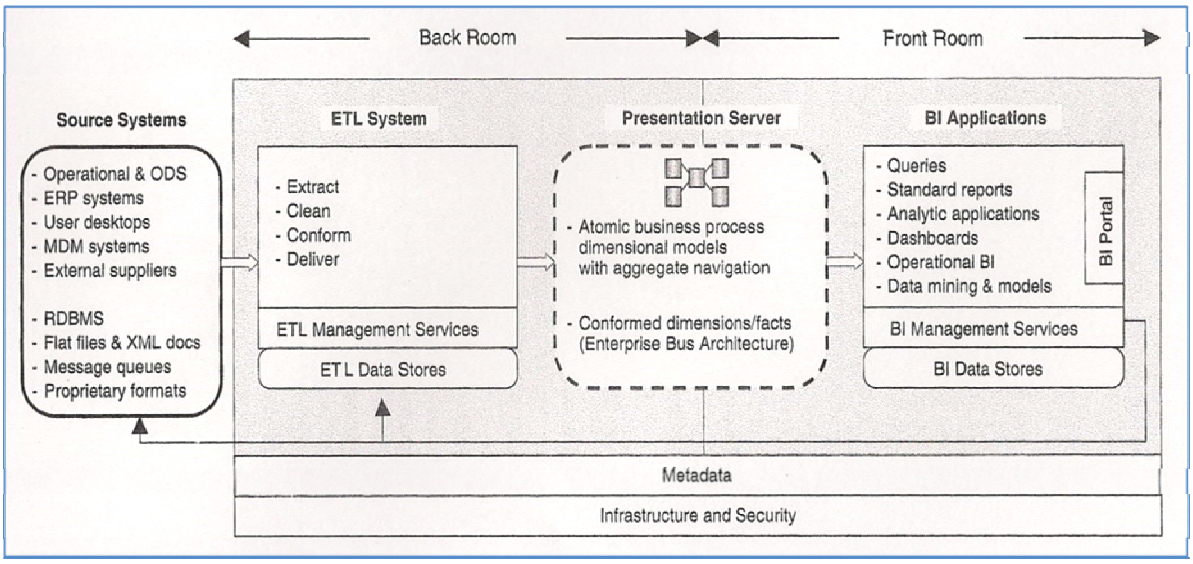


Figure 8 – High-level DW/BI System Architecture Model. Source: (Kimball *et al.* 2008, p. 114)

5.3. System Model (Designer's View)

The system model of the DW/BI from the designer's perspective is a logical model of the entities and relationships to be included in the system. For a DW/BI system this would be in the form of a dimensional data model, also known as a star schema (Hoffer *et al.* 2007, p. 453). According to Kimball *et al.* (2008, p. 234) dimensional modelling is a logical design technique for structuring data so that it is intuitive to business users and delivers fast query performance.

A dimension model is created for each of the business processes identified in the business process model e.g. order processing or payment processing defined in the owner's perspective. The dimension model consists of fact tables and dimension tables. Fact tables contain quantitative data about the business such as order amount, quantity ordered. Facts

are sometimes referred to as measures. Dimension tables contain descriptive data about the subjects of the business e.g. Product or Store. They are the attributes of the subject such as product description, colour, size or store name, location etc. Each dimension table has a one-to-many relationship with the fact table.

Dimensional modelling involves selecting a business process to be modelled e.g. order processing, declaring the grain (the lowest level of detail), identifying the dimensions and identifying the measurements. Dimensional models stored in a relational database are typically referred to as star schemas and dimensional models stored in multidimensional online analytical processing (OLAP) structures are called cubes. (Kimball *et al.* 2008, p. 237). Figure 9 shows a dimension model example in the form of a star schema. The dimensions are Product, Period and Store and the measures are stored in the Sales table.

Granularity refers to the level of detail or summarisation of the units of data in the data warehouse. It affects the volume of data that resides in the data warehouse and the type of query that can be answered. (Inmon 2005, p. 41). For example, if the business users want to report on the number of online orders placed by customers per hour and the highest level of granularity is a summary per month, the users' requirements will not be satisfied. The highest level of granularity for the example in Figure 9 is a day.

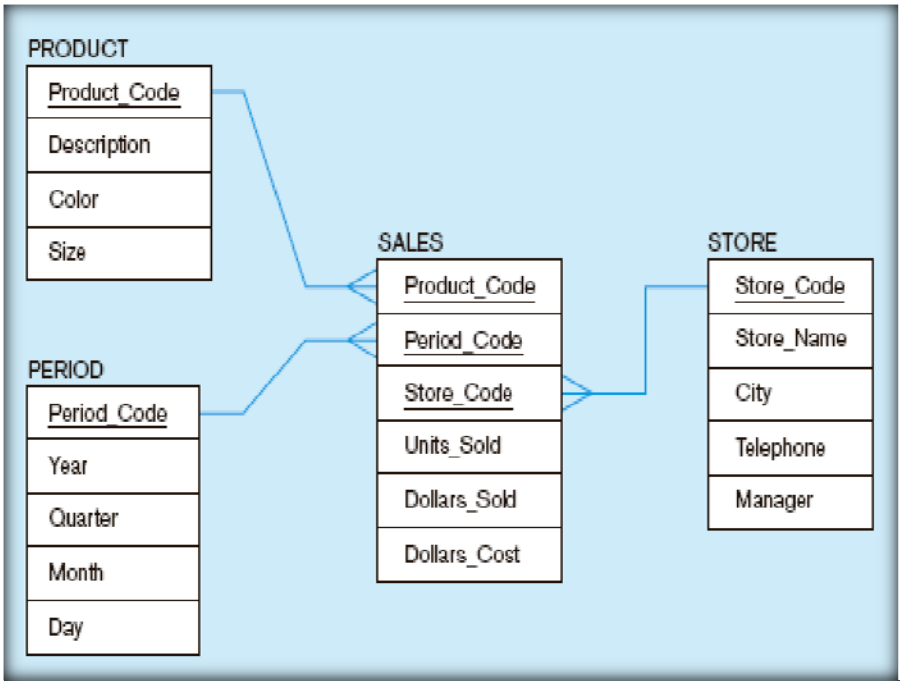


Figure 9 - Dimension Model Example. Source: Hoffer *et al.* (2007, p. 454)

The second column for the back room function is the design of the ETL process. According to Kimball *et al.* (2008, p. 370-371), the business needs for the ETL process are the DW/BI system users' information requirements; this is the information content that business users need to make informed business decisions. The business needs directly drive the choice of data sources and their subsequent transformation in the ETL system.

Extraction involves identifying and capturing the relevant data from the source files and databases used to fill the EDW. Extraction routines are created, usually by an extraction tool to extract the data and load it into a staging area. The data is cleansed by identifying errors and rejecting any that are erroneous and sending it back to the source system for correction. Only clean data is loaded into the staging area. The data is then transformed from the format of the operational source system to the format of the EDW and finally it is loaded into the EDW. The initial load is a static extract i.e. a snapshot-in-time and further loads will be an incremental extract, updating the EDW with changes since the last load (Hoffer 2007, p. 444). Figure 10 shows a visual representation of the ETL process.

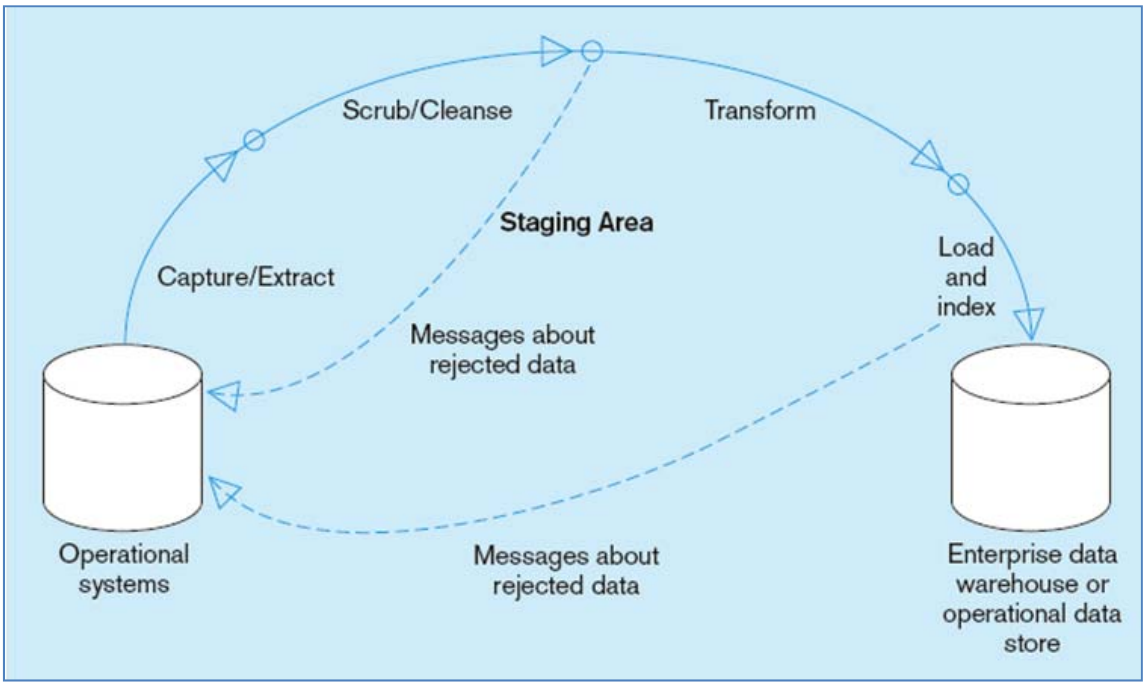


Figure 10 - ETL Process. Source: Hoffer *et al.* (2007, p. 442)

The front room for the second column addresses the design of the BI applications. This is discussed in the next chapter so will not be addressed here other than to include a statement given by Kimball *et al.* (2008) when discussing the importance of BI applications:

"For the majority of business users, the BI applications are the only view of the DW/BI system they will have. If the applications are confusing, perform poorly, are unappealing or inaccurate, they will taint the entire DW/BI system. Many of these users will turn to alternative sources for information, or worse, start projects to build their own data warehouse or marts".

The third column is the design of the DW/BI architecture. Most EDWs follow three-layer architecture. Figure 11 shows an example of three-layer architecture. The first layer consists of data distributed throughout the various operational systems. The second layer is an EDW, which is a centralised, integrated data warehouse that is the control point and single source of all data made available to end users for decision support applications. The third layer is a series of data marts. A data mart is a data warehouse whose data is limited in scope for the decision-making needs of a particular user group. A data mart can be independent of an enterprise data warehouse, derived from the EDW or a logical subset of

the EDW. (Hoffer et al. 2007, p. 471). Users can access a data mart for decision support applications and access the EDW warehouse for other information.

Data is extracted from the internal and external source systems, transformed and loaded into the EDW. End users query the EDW using a variety of query languages and analytical tools.

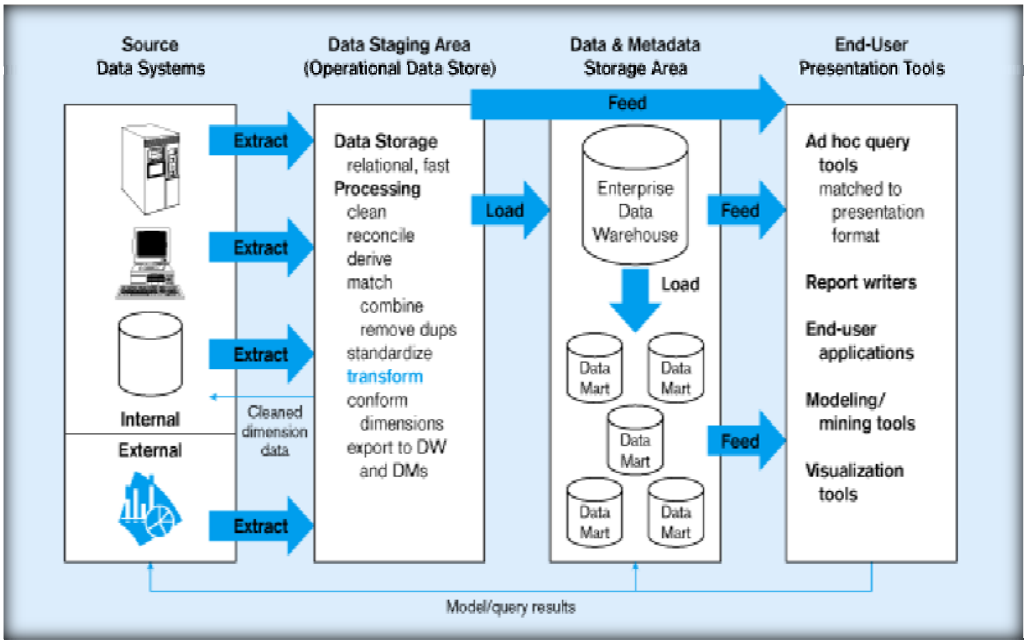


Figure 11 - Dependent Data Mart and Operational Data Store: a Three Level Architecture. Source: Hoffer *et al*. (2007, p. 431)

5.4. Technology Model (Builder's View)

The technology model defines the physical design from the builder's perspective. The first column is now dealing with data tables rather than the dimensions in the logical design (see Figure 12).

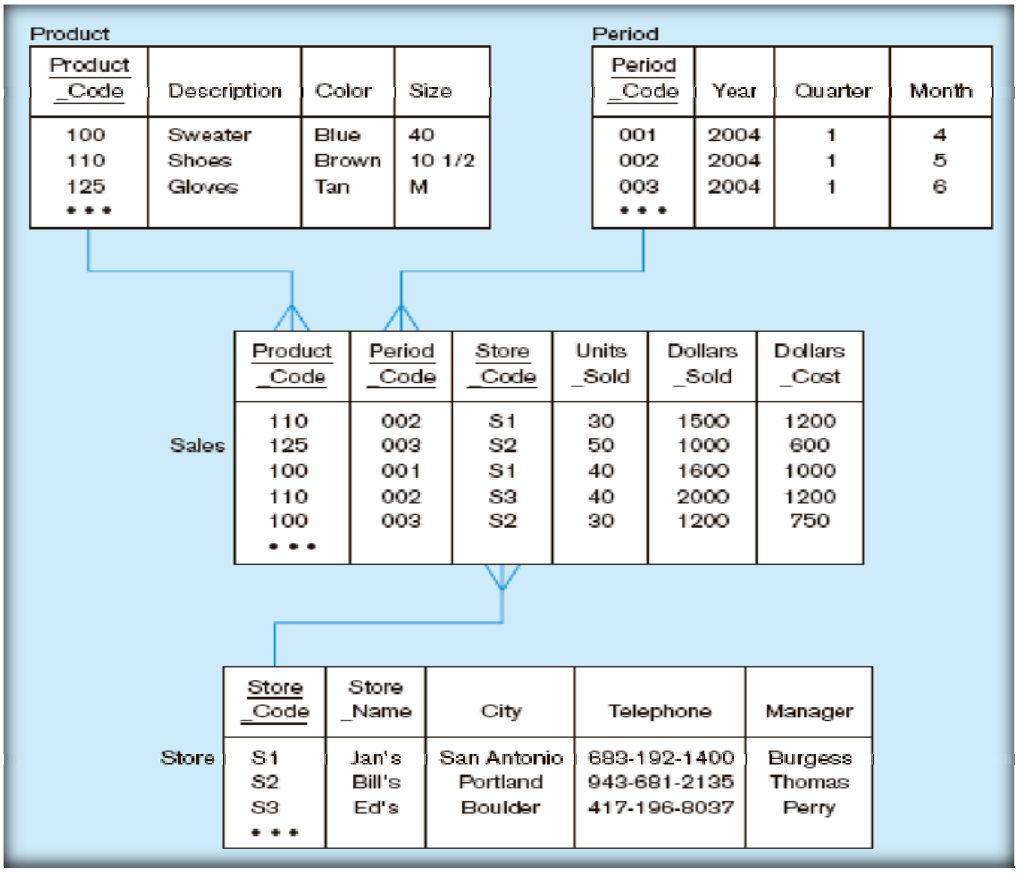


Figure 12 - Star Schema with Sample Data. Source: Hoffer *et al.* (2007, p. 455)

The back room considers the physical data warehouse design which implements the logical model. The physical design describes the actual implementation of the tables by a particular RDBMS including physical database characteristics such as data types, indexes and table partitioning. Also included in the physical design are the data staging tables that are used by the ETL process before the data is loaded into the EDW.

The front room addresses developing the BI applications that were identified in the design stage. This may include installing third party software to support decision support, reporting and analysis tools and developing an initial set of reports and applications; or developing bespoke applications.

The discussion above has taken a brief look at a generic approach to developing a DW/BI system. It suggests that the needs of the BI Applications users will be satisfied if they are included in all stages of the system development lifecycle. The discussion continues in the next chapter to examine the needs of the business users in more detail.

6. THE BUSINESS INTELLIGENCE USER

To make timely business decisions, business users require simple and intuitive access to corporate data. Unfortunately, traditional business intelligence tools sometimes fail to meet the needs of many information workers. According to the one survey, less than 5% of information workers actually use BI tools today – even though these business users believe that they do not have all the information needed to make sound decisions. Knowledge workers often depend on IT, which in turn faces a backlog of requests that prevent timely responses. (SAP AG, 2009). According to another survey, the BI Survey 8, only 8% of employees are actually using the BI Tools and not the 20% as reported by BI Tool vendors (Swoyer, 2009).

Figure 13 shows the roles involved in a DW/BI system. The diagram is split into quadrants. The top left quadrant is related to information management. The roles in this quadrant form the main focus of this dissertation; they are the end users of DW/BI systems and include the executive users, business users, technical and business analysts. The bottom left quadrant shows the roles involved in the operational environment, these are mainly the users of the operational systems (OLTP). The top right quadrant refers to the external environment and is not discussed any further in this dissertation. Finally, the bottom right quadrant shows the roles of the system engineers who build and maintain the DW/BI system. The role of interest in this quadrant is that of the Developers who, as will be made clear later in the discussion, are supporting the roles in the upper left quadrant.

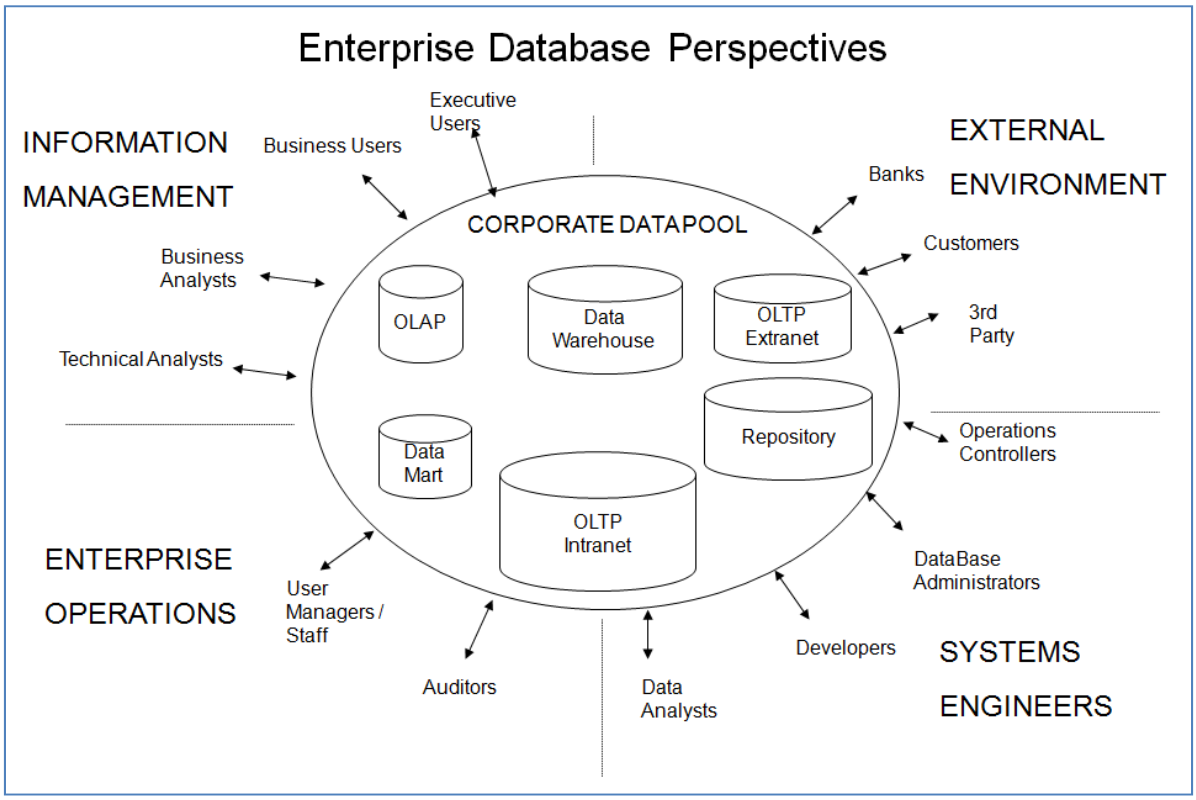


Figure 13 - Enterprise Database Perspectives. Source: Adapted from University of Chester Teaching Material

Having identified the roles involved in a DW/BI, Ponniah (2001, p. 235) suggests grouping the roles based on their job functions and the information they need to support their roles.

- High-Level Executives and Managers (Executive Users). Need information for high-level strategic decisions. Standard reports on key metrics are useful. Customised and personalised information is preferable.
- Technical Analysts. Look for complex analysis, statistical analysis, drill-down and slice-dice capabilities, and freedom to access the entire data warehouse.
- Business Analysts. Although comfortable with technology, are not quite adept at creating queries and reports from scratch. Predefined navigation is helpful. They want to look at the results in many different ways. To some extent, can modify and customise predefined reports.
- Business-Oriented Users (Business Users). These are knowledge workers who like point-and-click GUIs. Desire to have standard reports and some measure of ad hoc querying.

Later Ponniah (2001) identifies another user, the Operator.

- Operators (User Managers/Staff). This is mainly the administration staff who input the information into the OLTP systems on a day to day basis.

Furthermore, having established a way of grouping the users Ponniah (2001, p. 325) and also Inmon (2005, p. 457-460) suggest a way of classifying the users in terms of their access and information delivery practices and preferences. Figure 14 shows five broad classes of users. Within each class, the figure indicates the basic characteristics of the users in that class. The figure also assigns the users in the organisational hierarchy to specific classes.

According to Ponniah (2001) this classification of user provides us with a good basis to understand the characteristics of each group of users and suggests that it is possible to fit any user into one of these classes.

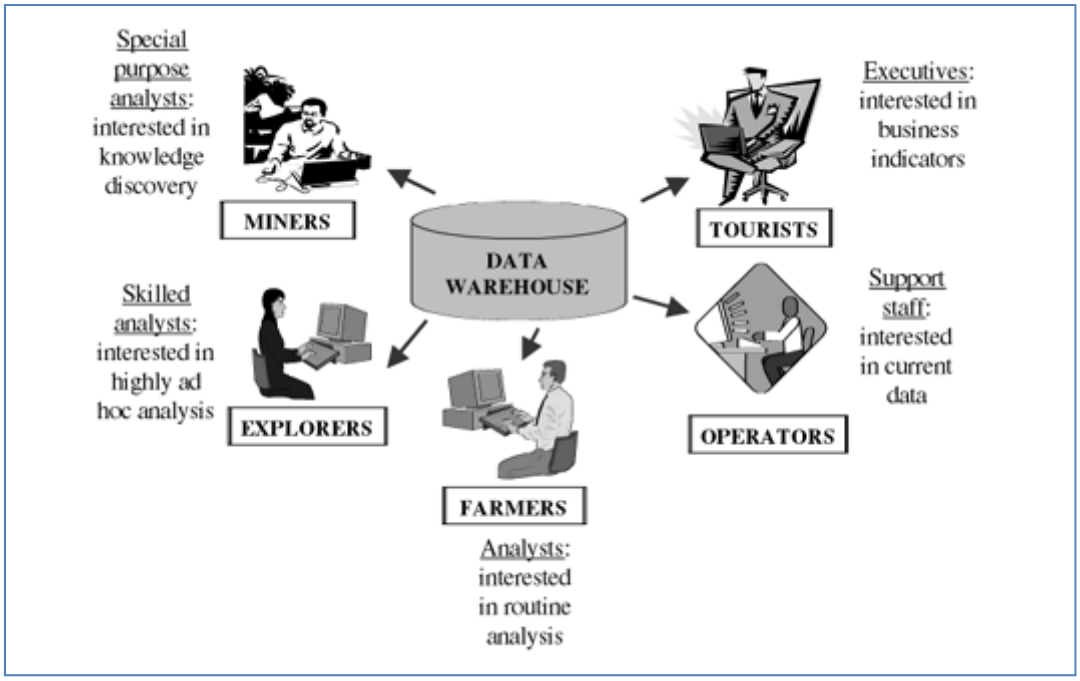


Figure 14 - Data warehouse User Classes. Source: Ponniah (2001, p. 325)

The groups of user in Figure 13 can be mapped to the classifications in Figure 14. The executives are the tourists; the user managers/staff are the operators; the business users are the farmers; the business analysts are the explorers and finally, the technical analysts are the miners.

7. THE BUSINESS INTELLIGENCE USER AND THE ZACHMAN FRAMEWORK

We now look at how a DW/BI addresses the needs of the BI user, by using the Zachman Framework again, but this time concentrating on the front room column from Table 1 and by adding each of the business intelligence users identified in Section 6 to the rows of the framework. The Business Intelligence applications can be considered from each user's

perspective by addressing What? How? Where? Who? When? And Why? questions in a structured approach. Table 2 shows the requirements of BI applications from the perspective of each of the five categories of user followed by a description of each of the cells in the matrix.

DIMENSIONS PERSPECTIVES	WHAT DATA	HOW FUNCTION	WHERE NETWORK	WHO PEOPLE	WHEN TIME	WHY MOTIVATION
TOURISTS	Highly summarised data	Simple user interface offering standard reports incorporating dashboards, customised and personalised, limited drill-down	Reports delivered via an online portal or email	Executives	Routine intervals	High level strategic decision making
FARMERS	Specific subsets of data, current and historical	Query and reporting tools. Standard reports, OLAP tools	Reports delivered via an online portal or email. User interface to OLAP cube	Technical analysts or specialist analysts e.g. marketing or finance analyst; managers or business planning groups	Consistent e.g. every week or month	Status of business under their management
MINERS	Detailed data including historical	Knowledge discovery and data mining	Data mining tools, statistical analysis tools, data visualisation tools. Specific data marts	Special purpose analysts	Unpredictable ad hoc basis	Look at specific problems sometimes raised by explorers
EXPLORERS	Large volumes of detailed data, current and historical	OLAP tools	Data warehouse exploration, OLAP database	Skilled Analysts	Unpredictable, ad hoc basis	Looking for patterns and relationships
OPERATORS	Current data at detailed level. Scope large	Standard reports	Reports delivered via an online portal or email	Support Staff or first line managers	Regular quick access	Assess current state of the business

Table 2 - Zachman Framework and Categories of User

7.1. Tourists

Who - Tourists are the executives in a company; they are the decision makers and are interested in a broad business perspective and an overall view of the health of the company.

What - Highly aggregated broad range of data.

How - The tourist needs an easy-to-use interface, with standard reports incorporating a digital dashboard showing key measures, so they can select topics and drill down to areas of interest and have alerts or alarms sent to them that signal the need to investigate something that has happened.

Where - The reports may be delivered via an online portal or via emails. They are likely to access meta data.

Why - The executives and senior managers are involved in high-level strategic decision-making and they need information from the DW/BI to help inform their decisions.

When - Reports are needed at routine intervals to enable the executive to keep a regular check on the status of the business.

7.2. Farmers

Who - Farmers are the most predominant of users, they usually come from the management or business planning groups e.g. they may be sales and product analysts determining how well a product is selling in some part of the world (Imhoff & Pettit, 2004).

What - The Farmer is interested in small specific subsets of data, both current and historical that affect his/her domain, e.g. weekly sales figures for the region they manage.

How – Farmers need automated reports that are summarised and aggregated to a fairly high degree with the ability to drill down into one or two layers of data, but rarely to the lowest level of detail (Imhoff & Pettit, 2004). They use query and reporting tools, standard reports and OLAP tools.

Where - They are likely to access a subject-oriented data mart.

Why - The Famer wants to be informed of the status of the organisation under their management.

When - The Farmer's usage is predictable and consistent, they will run the same activity on a routine basis, e.g. look at sales figures every Monday morning.

7.3. Explorers

Who - Explorers are researchers and highly-skilled technical analysts. (Ponniah 2001, p. 328).

What – Explorers tend to look at large detailed data masses, submitting random queries to look for data patterns and relationships between events. They tend to work in heuristic mode not knowing what the next step will be until the results of the current set are complete.

How - The needs of the Explorer are very different to the needs of the users described above. They need to be able to submit random queries run on specialised exploration databases, OLAP, data mining and visualisation tools. They may use a specialised data mart where the data is drawn from the data warehouse just for their use.

Typically, Explorers create hypotheses out of their analyses. They then pass these hypotheses to the data miner for proof or disproof and an analysis of the strength of the hypothesis. Often the Explorer will create a repeating query of his or her findings and then pass that query on to the Farmer for routine creation.

Where - Data warehouse or exploration warehouse.

Why - Look for data patterns and relationships between events and create hypotheses out of their analyses. They then pass these hypotheses to the data miner for proof or disproof and an analysis of the strength of the hypothesis.

When - They use the data warehouse in a highly random manner and on an irregular basis. They also tend to operate on a project, when the project is finished the exploration process is complete (Inmon 2005, p. 458).

7.4. Miners

Who - Miners are special-purpose analysts with highly specialised training and skills. Miners adopt various techniques and performs specialised analysis that discovers clusters of related records, estimation of values for an unknown variable, grouping of products that would be purchased together, and so on (Ponniah 2001, p.328). The Miner digs into piles of data and determines whether it is saying something or not.

Miners often have a very good idea of what they expect before they execute a query. They set up queries based on this preconceived notion. For example, they may set up a query to determine the frequency of submission of claims with the likelihood of fraudulent claims. They may set up a query to determine the likelihood of two products being purchased together (market basket analysis) or one to determine the pattern of equipment failures (mean time to failure) and so on (Imhoff & Pettit, 2004).

What - They tend to look at data at the very lowest level and their queries are enormous. They also operate in a heuristic manner (Inmon, 2005, p. 459). Miners scan large amounts of detailed data looking for the confirmation of a hypothesis or for suspected patterns of activities (e.g. buying habits of valued customers, fraudulent claims). These massive amounts of data must be of high quality and/or consistent.

How - Data mining tools and techniques.

Where - Data warehouse, exploration warehouse or a specialised data mining data mart.

Why - Look at specific problems sometimes raised by explorers.

When - Unpredictable ad hoc basis.

7.5. Operators

Who - Operators are usually the administrative or clerical staff in an organisation. They are the most common set of users (Inmoff & Pettit, 2004). They may be individuals functioning in the role of first or second level managers, line or shift supervisors, or even customer service representatives.

What - They address the current state of the business so do not tend to be interested in historical data. They do need a broad range or scope of data.

How - Standard reports accessed by a simple user interface**.**

Where - Report portal, email.

Why - Assessing the current state of the business.

When - they normally need current detailed information on a regular scheduled basis e.g. weekly.

This chapter has described the user profile for each of the five classes of user, looked at the type of data they are interested in, their typical usage patterns and the type of user interface that will suit their needs. The next chapter describes the types of user interface in more detail.

8. BUSINESS INTELLIGENCE APPLICATIONS

There is not a one-to-one relationship between the class of DW/BI user and an interface that suits their needs e.g. an interface providing standard reports may be used by Operators, Farmers and Tourists. Table 3 shows a mapping between typical BI tools and the class of user, followed by a description of each of the BI tools identified in the table.

BI User	**BI Tool**
Tourist	Dashboards and scorecards
Operator, Farmer, Tourist	Standard reports
Data Miner	Data mining tools
Explorer, Farmer	OLAP tools
Farmer, Explorer	Query and reporting tools

Table 3 - BI Tools to Support the Five Classes of User

8.1. Dashboards and Scorecards

Dashboards and scorecards provide the tourist with a combination of reports and charts that use exception highlighting and drill-down capabilities to analyse data from multiple business processes. Figure 15 shows an example of an interactive report incorporating

charts and dials. The dials show data at a very high summary level e.g. total orders delivered on time. If the dial was pointing in a red area, the user may want to drill down to the data behind the dial figure to, for example, identify warehouses with low scores for delivering orders on time.

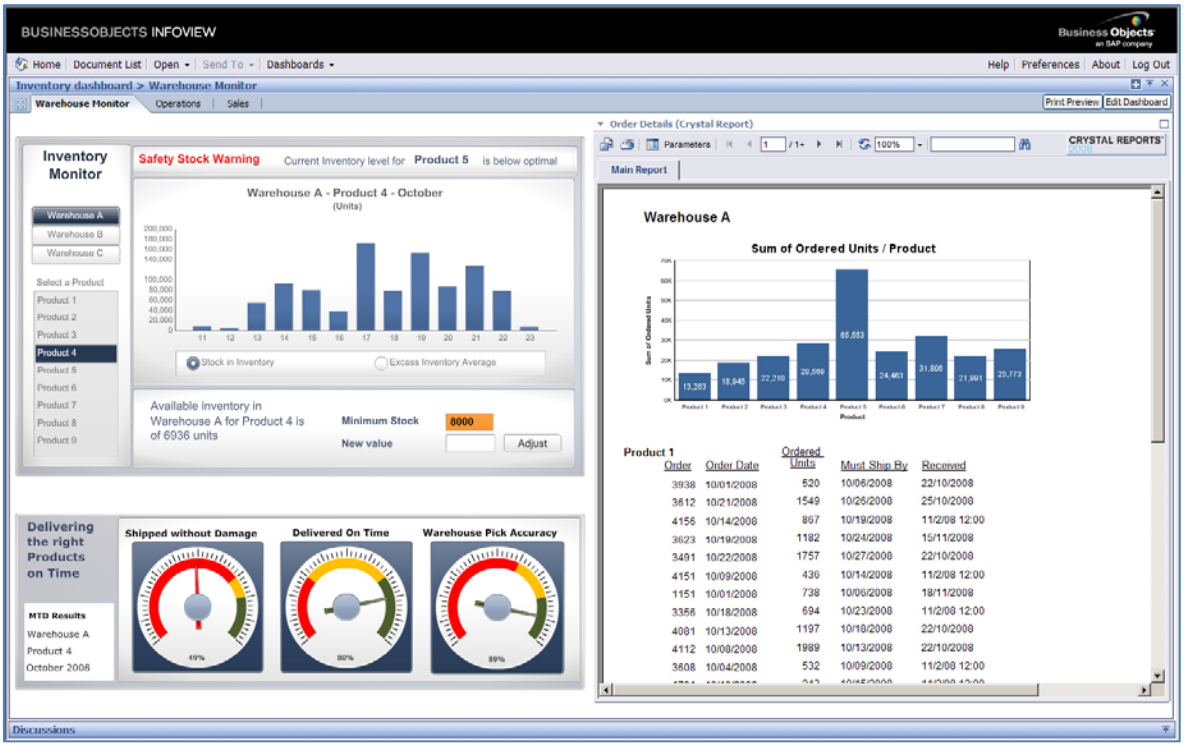


Figure 15 - SAP Business Objects Dashboard. Source: http://www.sap.com/americas/solutions/sapbusinessobjects/sme/reporting/crystalreportsserver/featuresfunctions/images/inventory_monitor.jpg

8.2. Query and Reporting Tools

These tools allow users to query the dimensional model directly and define a results set. Simple ad hoc tools only deliver tabular results sets, whereas more advanced tools allow the creation of fully-realised, complex reports. In these cases, the ad hoc tools also serve as the development tools for standard reports that other users run themselves. (Kimball *et al.* 2008, p. 479).

8.3. Online Analytical Processing (OLAP) Tools

OLAP tools are graphical tools that provide users with multi-dimensional views of their data and allow them to analyse the data using simple windowing techniques. (Hoffer *et al.* 2007, p. 467). Figure 16 shows a three dimension cube which analyses products by time and by the measures Units, Revenue and Cost. The user can analyse the cube data by

slicing and dicing and drilling down into the detailed data. Figure 16 shows a slice of the cube by looking at shoes in the product dimension. The table on the right shows the 'slice' of the cube.

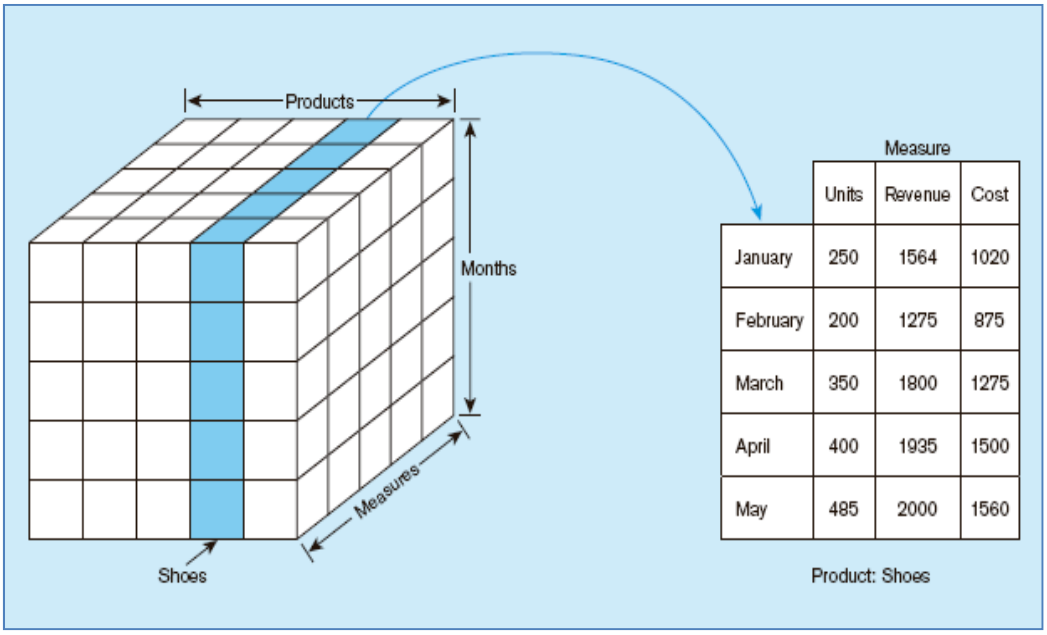


Figure 16 - Slicing a Data Cube. Source: Hoffer *et al.* (2007, p. 467)

Figure 17 shows how the summary data for the brand 'Soft Towel' can be drilled down to show how the different pack colours contribute to the summary figures.

Figure 17 - Example of Drill-Down. Source: Hoffer *et al.* (2007, p. 468)

8.4. Data Mining Tools

Data mining is a process of data exploration with the intent to find patterns or relationships that can be made useful to the organisation (Kimball *et al.* 2008, p. 494). The tools usually support explanatory exploration where the data is explored to explain an event or condition; confirmatory exploration to confirm a hypothesis; and exploratory to analyse data from new or unexpected relationships (Hoffer *et al.* 2007, p. 469). Figure 18 shows examples of the application areas of data mining.

Application Area	Examples of Mining Functions	Mining Processes	Mining Techniques
Fraud Detection	Credit card frauds Internal audits Warehouse pilferage	Determination of variations from norms	Data Visualization Memory-based Reasoning
Risk Assessment	Credit card upgrades Mortgage Loans Customer Retention Credit Ratings	Detection and analysis of links	Decision Trees Memory-based Reasoning
Market Analysis	Market basket analysis Target marketing Cross selling Customer Relationship Marketing	Predictive Modeling Database segmentation	Cluster Detection Decision Trees Link Analysis Genetic Algorithms

Figure 18 - Data Mining Functions and Application Areas. Source: Ponniah (2001, p. 409)

Data mining can be broken down into five major categories: clustering, classifying, estimating and predicting, affinity grouping and anomaly detection (Kimball *et al*. 2008, p.496).

Clustering - Clustering means forming groups (Kimball *et al.* 2008, p. 496) and is a data mining technique which looks for groups or clusters of data elements that are similar to one another. For example, a life insurance company may look at clusters of retired customers and offer them products directed at that target group. Figure 19 shows an example of a cluster diagram with two variables, length of time as a customer and the total amount they have spent. Clusters of customers (circled in the diagram) can be identified to see if there is any relationship between the two variables.

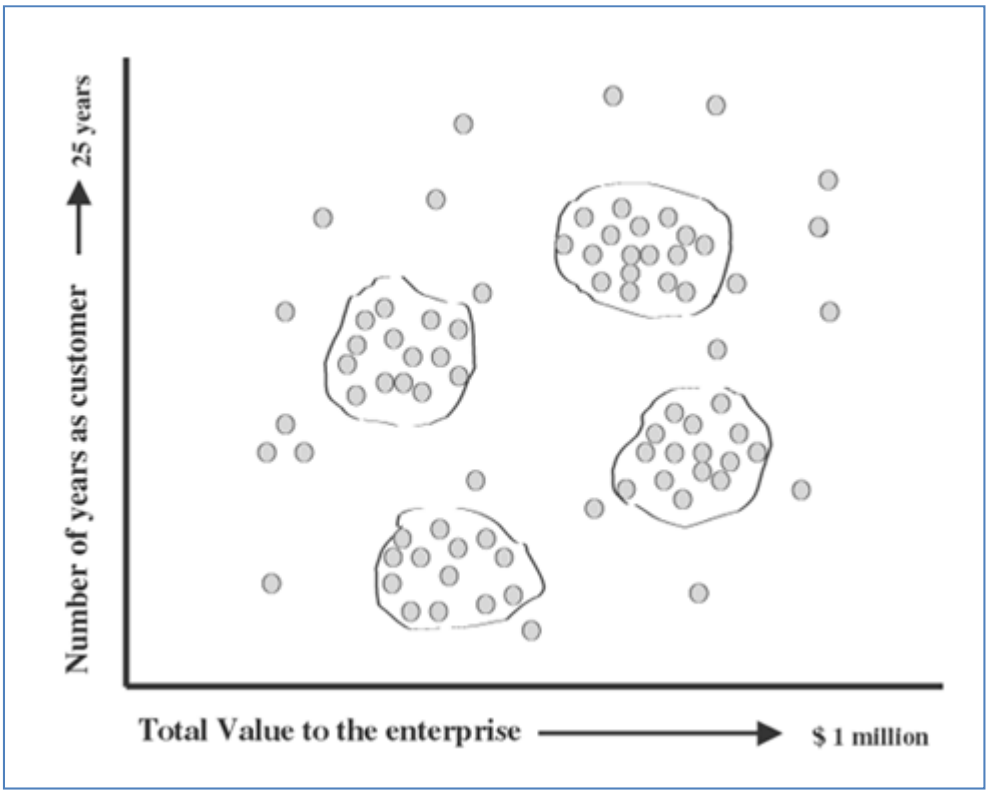


Figure 19 - Clusters with Two Variables. Source: Ponniah (2001, p. 411)

Classifying - Classification is the task of assigning each item in a set to one of a predetermined set of discrete choices based on its attributes or behaviours, e.g. consumer goods are classified in a standard hierarchy down to the SKU level (Mundy *et al*. 2006, p. 424).

Estimating and Predicting - Estimating and predicting are similar activities. Estimation involves the use of statistical techniques to estimate values of an unknown variable and predicting estimates the future values of a variable.

Affinity Grouping - Affinity grouping looks for correlations among the items in a group of sets e.g. analysing why items are sold together at the same time. Amazon uses affinity grouping to offer purchase suggestions.

Anomaly detection - This is looking for cases that deviate from the norm.

8.5. Standard Reports

Standard reports are the simplest way to access the data in the DW/BI and are traditionally created to a predefined format to provide users with business information. Reports may be run regularly and distributed automatically. They generally provide some level of user

interaction, like the ability to enter a parameter, drill down to a lower level of detail, and link to related reports (Kimball *et al.* 2008, p. 479-480).

A typical report could be one that runs weekly and is distributed every Friday via email to show weekly sales figures for each region in an organisation.

Rasmussen, Goldy and Solli (2002, Chapter 7) provide an explanation to some of the features found in standard reports:

Drill-down - This is an action that allows a user to navigate lower within a dimensional hierarchy and enables us to see what information is driving a single aggregated value.

Standard chart/graphs - Support of standard business charts is a key part to information delivery in BI e.g. bar, horizontal bar, pie, area, line, point, etc.

Exception highlighting - This is also sometimes called *alerts*, wherein information consumers are allowed to specify their own parameters for highlighting values and how those values are to be displayed.

Combo views - This refers to the ability to make a combination chart in which a line and bar chart can be on the same graph and be able to show two different Y-axes that have differently-scaled values.

Pivot rows and columns - This is a fundamental feature for most BI tools. It allows the values that are shown on the rows and columns to be interchanged. The values on the rows are moved to the columns, and the values on the columns are moved to the rows.

User-defined custom calculations - This means placing the ability to create metrics that are important to information consumers into their hands.

Expose queries - This refers to the ability to "hand-modify" the language or script that defines a query in a BI tool. Some tools expose this and the usage of it would be by power users, individuals who need to "tweak" an existing query to get exactly what they want and what they cannot get from the user interface of that tool.

Qualitative comments - Augmenting a view of information with qualitative comments can offer the extra credit needed for real information value. The objective is to share the comments with others interested in the same information.

Distribution of cubes/reports - This is critical to sharing information. The two items of cubes and reports are tied together because with this combination the information consumer has the ability to drill down into the cube information - all from within the same report.

Sorting and filtering - By filtering the data, you can work with a smaller subset of the members and reduce the time required to return a response from a query. Sorting is often useful to see the items sorted by the measure being viewed.

9. PART ONE SUMMARY

To summarise, the discussion in Part 1 looked at the history of DW/BI systems and described a generic approach to developing a system. The Zachman Framework and Kimball's lifecycle approach were combined to provide a structured framework on which to base the discussion. The users of a DW/BI were analysed and the types of applications that support their needs were discussed, again using the Zachman Framework.

The main theme of the discussion emphasised the view that for the successful development of BI applications the BI user's needs should be addressed from the requirements stage, and the development of BI applications should run as a parallel activity alongside the data warehouse development activities. The BI applications should be developed by BI developers who have knowledge of the business, rather than technical IT staff. This view is supported by leading DW/BI authors such as Ralph Kimball. The research also found the needs of the BI application users can be analysed by grouping them into one of five classifications of user – Tourists, Farmers, Explorers, Miners and Operators and that different user interfaces are needed to support their needs.

PART TWO

10. CASE STUDY

Unilever, a multi-national corporation, is one of the world's leading suppliers of consumer product brands in foods, beverages, cleaning agents and personal care products.

Unilever generates vast amounts of data about their products from a multitude of disparate systems all around the world. SAP's BusinessObjects Data Integrator is used to extract data, transform it into usable business data and load it into a single SAP business warehouse. The data warehouse feeds into specific data marts (InfoCubes) and is made available to relevant end users (SAP Business Objects, 2008).

Business intelligence is delivered to the planning managers in the European Plan Process Office within Unilever, by software called SAP Business Explorer (BEx) which connects to an info cube in the DW/BI and runs embedded queries to extract data to an Excel workbook (see Figure 20). Front room support to the 'InfoCube' is provided by a BW technical team.

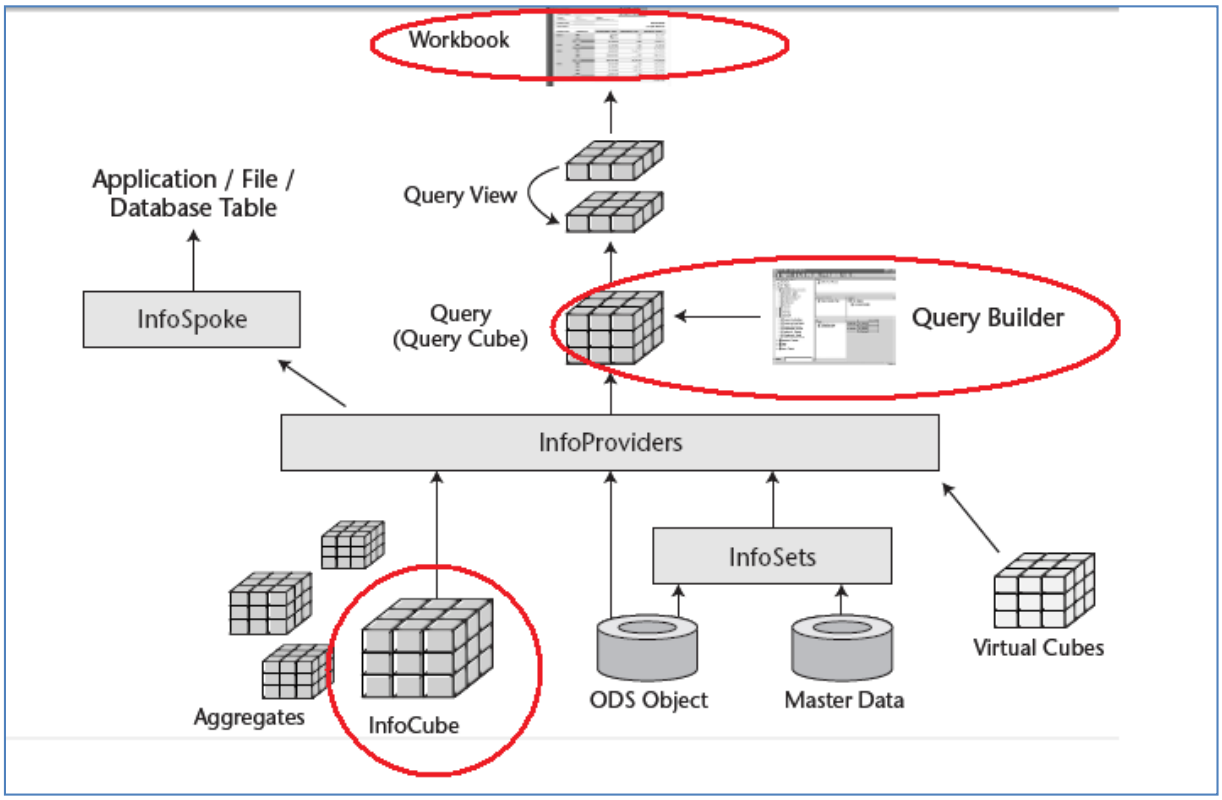


Figure 20 - SAP Analysis Processing. Source: McDonald (2002)

Figure 21 is a visualisation of the InfoCube named ‘InfoCube 30’ which contains the key figures (measures) and dimensions of sales and forecasting data used in the S&OP Reports.

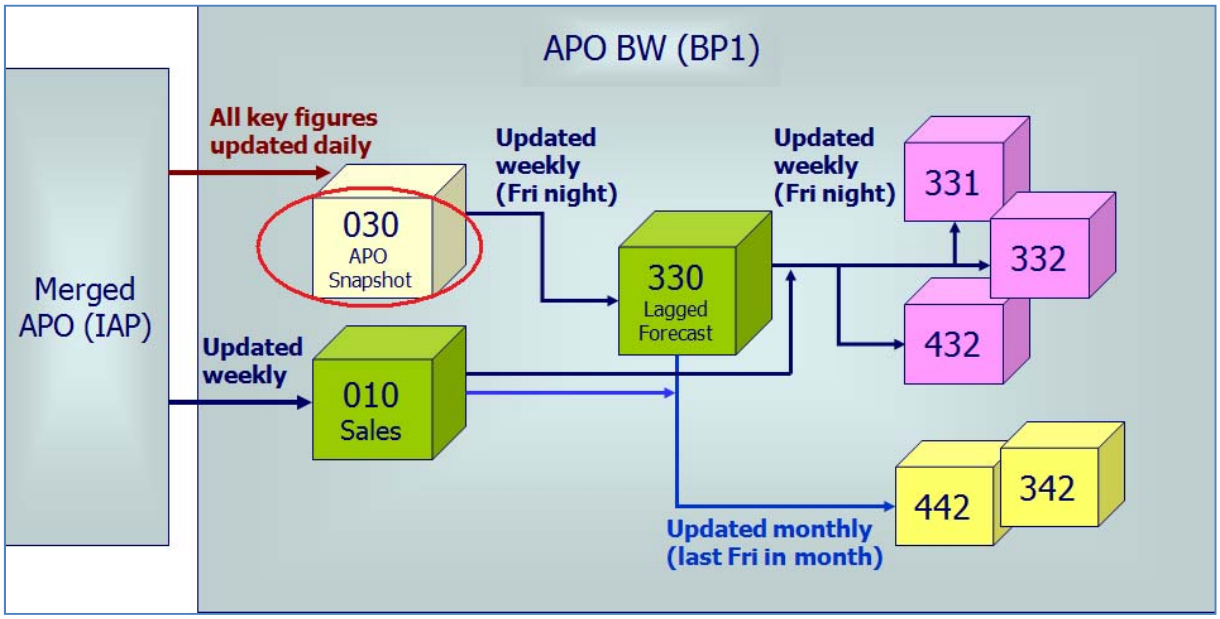


Figure 21 - Data Planning InfoCube 30

Authorised planning managers have access to the InfoCube to develop or modify the queries embedded in the workbooks. Figure 22 shows the key figures and dimensions that are used in the queries developed against ‘InfoCube 30’ and embedded in the Excel workbook.

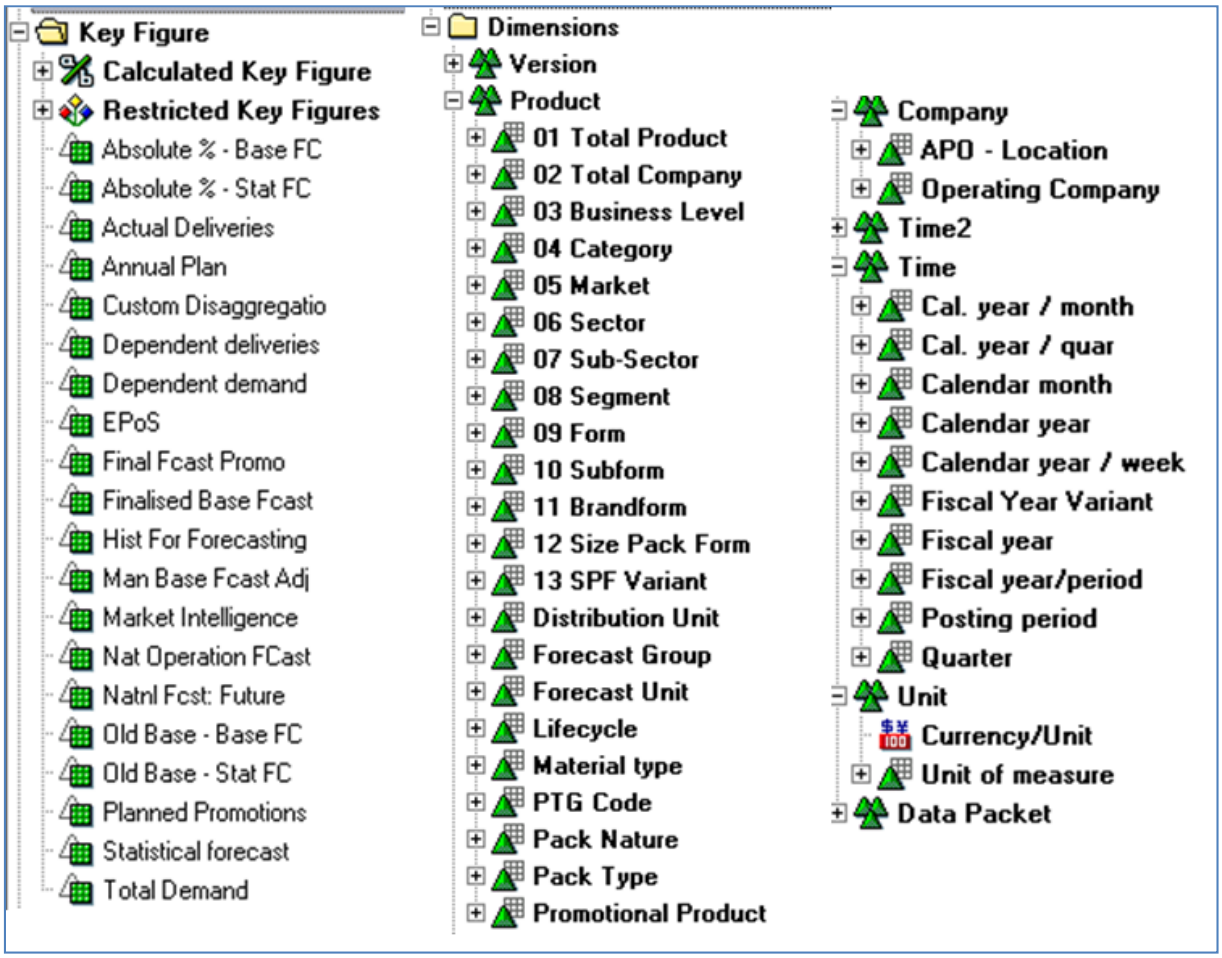


Figure 22 - Key Figures and Dimensions

The embedded query provides the base data for the reports, but much of the processing of the business data is performed in the workbook using Visual Basic (VB) and macros to produce reports and graphs. The reports, known as the S&OP (Sales & Operations Planning) Reports provide an analysis of rolling forecast figures and key performance indicators and are used by the planning offices throughout Europe to provide managers with information to inform decisions, and to input into their product forecasting meetings. The data is refreshed from within the S&OP Reports by running the BEx query with a set of parameters, see Figure 23.

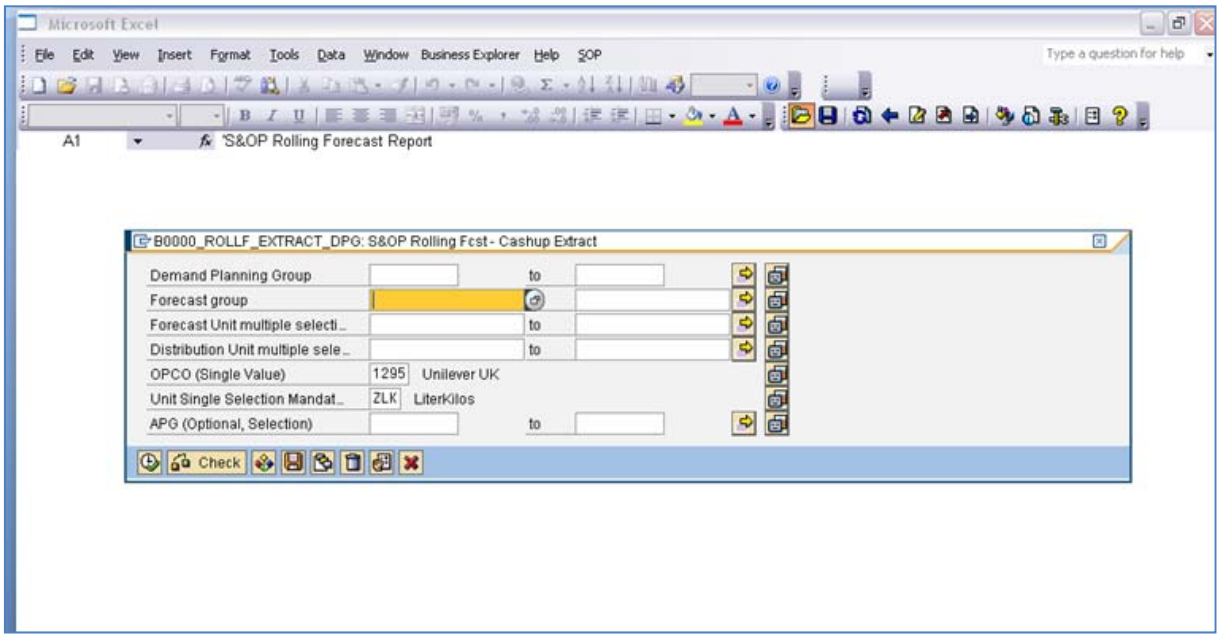


Figure 23 - SAP Business Explorer Parameters

Refreshing the query triggers the VB code to be executed and the data is presented in the form of drillable worksheets, pivot charts and graphs. See Figure 24 for a visual overview.

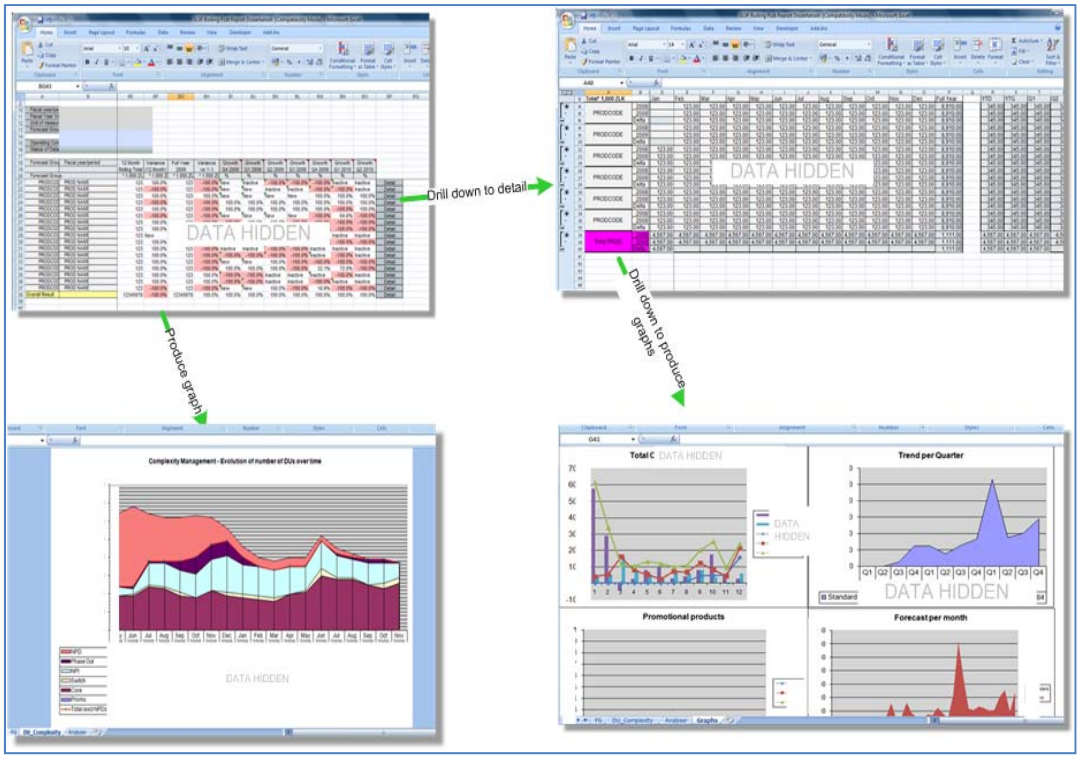


Figure 24 - Reports and Graphs

The S&OP reports provide the planning managers with the business intelligence they need to make business decisions. The main problem with this solution is that business users have in effect access to predefined parameterised reports that have been developed by back room staff

(software developers in the bottom right quadrant of Figure 25) and are being used to support the BI requirements of the group. On-going access is needed to the software developers in order to provide flexibility and further development of the functionality designed into the reports.

The discussion in Part One suggests that DW/BI solutions are intended to give the ability to get information to the business users with reduced reliance on the back room staff. However, the SAP BEx interface falls short of delivering a complete DW/BI solution. Its dependence on Microsoft Excel means that users can analyse their data and produce graphs etc. but the problems begin when more advanced functionality is needed that can only be achieved using macros and VB code.

Using Ponniah's (2001) and Inmon's (2005) classification of BI users, the planning managers fall into the classification of Farmers, see Figure 26. We found from Part One that a successful BI application to support the Farmer is one that supports automated parameterised reports that are summarised and aggregated to a fairly high degree with the ability to interface with the data cube. The reports should be easily customisable and maintainable by front room staff as advocated by Kimball *et al.* (2008) (see the 'Who' column in Figure 26).

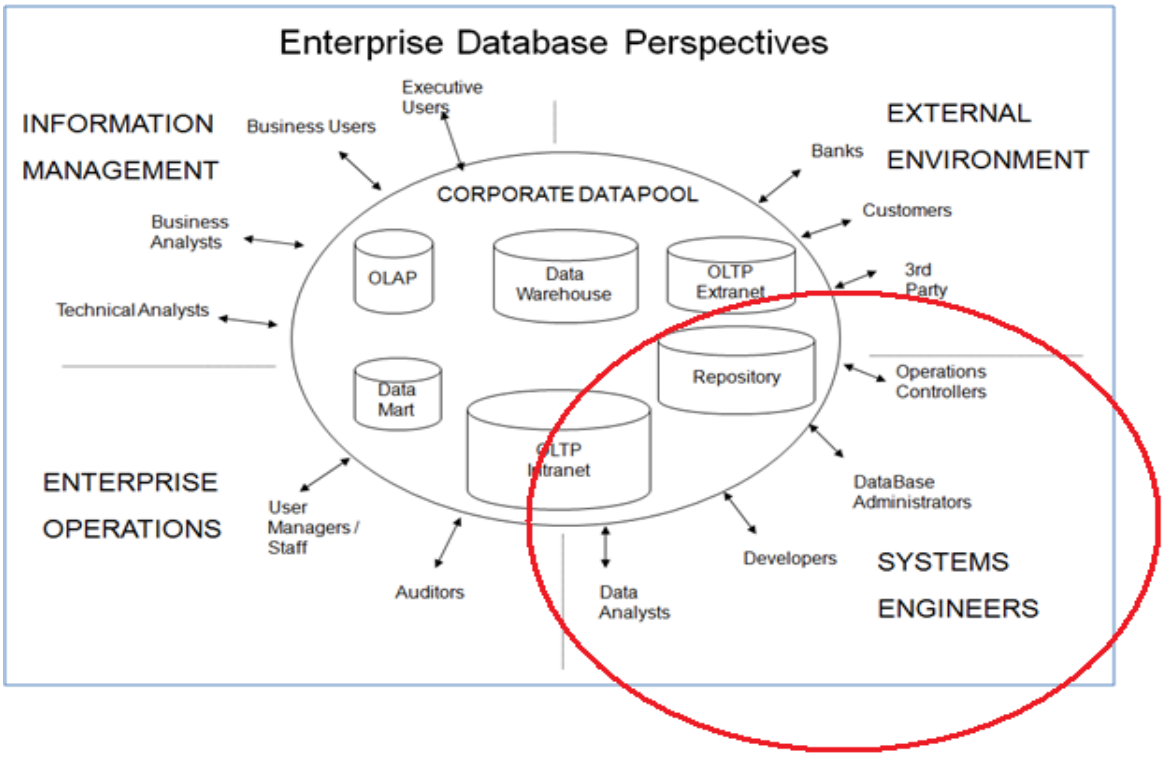


Figure 25 - Enterprise Database Perspectives. Source: Adapted from University of Chester Teaching Material.

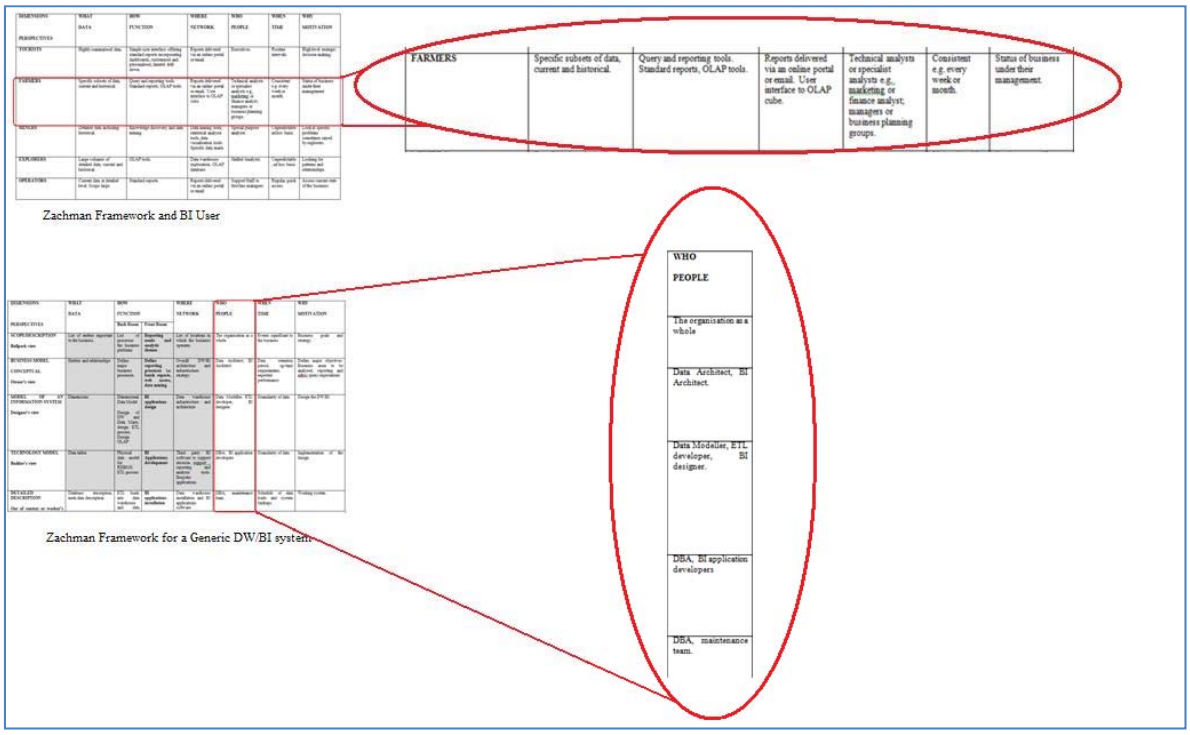


Figure 26 - Extracting the Farmers and the People Column for a Case Study.

11. REQUIREMENTS FOR A BI TOOL

The S&OP Reports application has been developed over time as requirements changed, and the code has become complex. By studying the application and code, UML use case and sequence diagrams were produced to gain an understanding of the application, and to analyse its functionality. The use case diagram is reproduced in Figure 27. The figure shows two levels of access to the reports, the Business Manager has access to view the reports and the Business Manager/Power User is able to refresh the reports with data from the InfoCube.

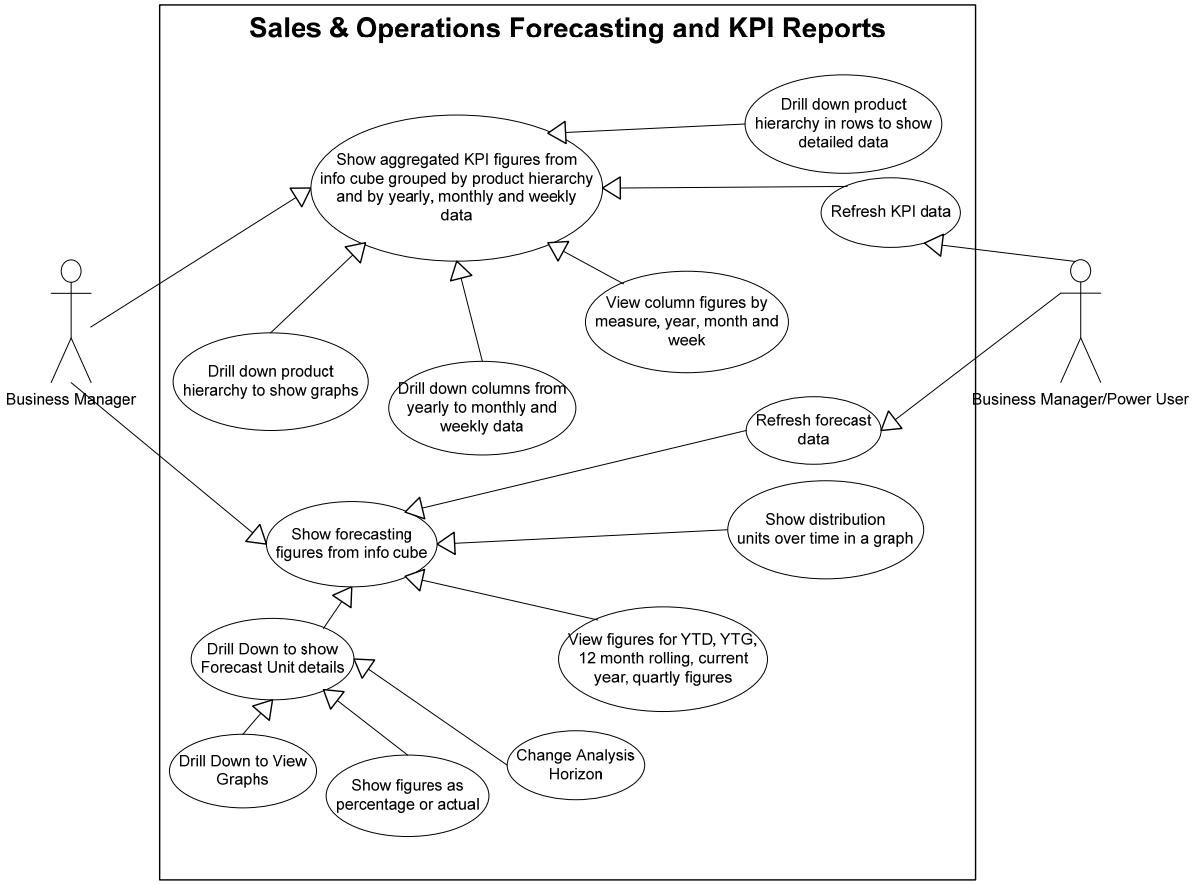


Figure 27 – Use Case for Bespoke BI Tool

The sequence diagrams are too large to be included in this report, however, they were studied and analysed to produce a list of requirements. The list of requirements is included in Appendix 1 and indicates where the requirement could be found e.g. in a sequence diagram, and which report the requirement relates to. The requirements list was used to populate Table 4 which is a matrix, the rows are a list of the requirements and the columns are the BI features identified in Part One. An 'X' in the box indicates the BI feature(s) which are needed for each requirement.

Feature Requirement	Drill-down rows and columns	Parameters	Standard charts and graphs	Pivot results	Column and row calculations	Exception highlighting	Qualitative comments	Sorting and filtering	Combo views	Grouping and sub-totals	User access	Drill-through	Dashboard	Report Publishing	Not supported
Drill-down from a Forecast Group (FG) to show Forecast Unit (FU) detail based on a user selection of "12 month rolling","Current Year", or "Next Year"	X	X													
Drill-down from an FU or total figure to produce graphs. Graphs to show: forecast totals for the period of analysis and a comparison of current year and previous year, and previous year -1 with previous year -2 forecast trend per quarter forecast totals for promotional products forecast totals per month	X				X				X						
Expand monthly to show weekly figures	X														

Feature / Requirement	Drill-down rows and columns	Parameters	Standard charts and graphs	Pivot results	Column and row calculations	Exception highlighting	Qualitative comments	Sorting and filtering	Combo views	Grouping and sub-totals	User access	Drill-through	Dashboard	Report Publishing	Not supported
Drill-down product hierarchy from Grand Total, Promotional Product, Forecast Group, Forecast Unit or Distribution Unit to produce graphs. Graphs to show: Visualizer – show bias and inaccuracy figures and 9 month moving average Visualizer forecast – show forecast and actual figures; and linear forecast and linear actual. Var_Inac – show variance inaccuracy for analysis period Var_Bias – show variance bias for analysis period	X		X						X						
Expand product hierarchy from Grand Total, Promotional Product, Forecast Group, Forecast Unit or Distribution Unit to show data	X														
Switch between showing the percentage or the absolute value															X

Feature Requirement	Drill-down rows and columns	Parameters	Standard charts and graphs	Pivot results	Column and row calculations	Exception highlighting	Qualitative comments	Sorting and filtering	Combo views	Grouping and sub-totals	User access	Drill-through	Dashboard	Report Publishing	Not supported
Change the months included in the analysis period between the current year, 12 month rolling or next year		X													
Display a different background colour for negative values						X									
Add comments to describe the meaning of figures							X								
Aggregate FG figures for current quarter, current quarter - 2, -1, + 1, + 2, + 3, + 4 and compare to same period one year earlier					X										
If FG data is nil for the previous year, show text in data cell as “New” or if data is nil for the previous two years, show text as “Inactive”															X

Feature / Requirement	Drill-down rows and columns	Parameters	Standard charts and graphs	Pivot results	Column and row calculations	Exception highlighting	Qualitative comments	Sorting and filtering	Combo views	Grouping and sub-totals	User access	Drill-through	Dashboard	Report Publishing	Not supported
Order Forecast Units by volume								X							
Show data for current year, year -1 and year -2					X										
Show months by name and not month number					X										
Show forecast and actual figures in different formats i.e. bar chart and line chart									X						
Add bars to show the differences ‘yr current vs yr-1’ and ‘yr-1 vs yr-2’					X										
Show rolling trend line on Visualiser_Fcst graph			X												
Show over forecast figures in red and under forecast in green						X									

Feature / Requirement	Drill-down rows and columns	Parameters	Standard charts and graphs	Pivot results	Column and row calculations	Exception highlighting	Qualitative comments	Sorting and filtering	Combo views	Grouping and sub-totals	User access	Drill-through	Dashboard	Report Publishing	Not supported
Ability to show next 6-12 month's forecast figures on the Visualiser_fcst graph			X												
Calculate current year total from data provided by the query					X										
Calculate 12 month rolling forecast total based on the sum of the current month through to 12 months in the future					X										
Calculate 12 month variance total based on 12 month rolling total divided by sum of previous year's 12 month rolling data. Display as percentage					X										
Calculate Variance vs Y-1 variance total based on current year total minus sum of previous year's data divided by sum of previous year's data. Display as percentage					X										

Feature / Requirement	Drill-down rows and columns	Parameters	Standard charts and graphs	Pivot results	Column and row calculations	Exception highlighting	Qualitative comments	Sorting and filtering	Combo views	Grouping and sub-totals	User access	Drill-through	Dashboard	Report Publishing	Not supported
Calculate totals from beginning of the year to date of data extraction					X										
Calculate totals from date of data extraction to the end of the year					X										
Show number of weeks and number of months the bias has the same sign (+ or -)					X										
All graphs and data to be printable to take to meetings														X	
Only relevant people should have access to the reports												X			
Show KPIs as dashboard													X		

Feature / Requirement	Drill-down rows and columns	Parameters	Standard charts and graphs	Pivot results	Column and row calculations	Exception highlighting	Qualitative comments	Sorting and filtering	Combo views	Grouping and sub-totals	User access	Drill-through	Dashboard	Report Publishing	Not supported
Show totals in FG sheet and when drilling down from FG to FU detail										X					

Table 4 - Matrix of Requirements and BI Tool Features

12. TEST DATA AND SOFTWARE

To ensure the privacy of the data owned by Unilever, a testing environment was set up to support the investigation into the features provided by the third party BI tools. Test data based on a food store from Kimball and Ross (2002) was used by importing it into a test database in SQL Server 2008. An OLAP cube was created and published using Analysis Services. Figure 28 shows a star schema for the testing database.

The star schema for the test database can be seen in Figure 28. Figure 29 is a much simplified star schema for the Unilever DW/BI and has been included to demonstrate the similarity of the test database being used in the investigation.

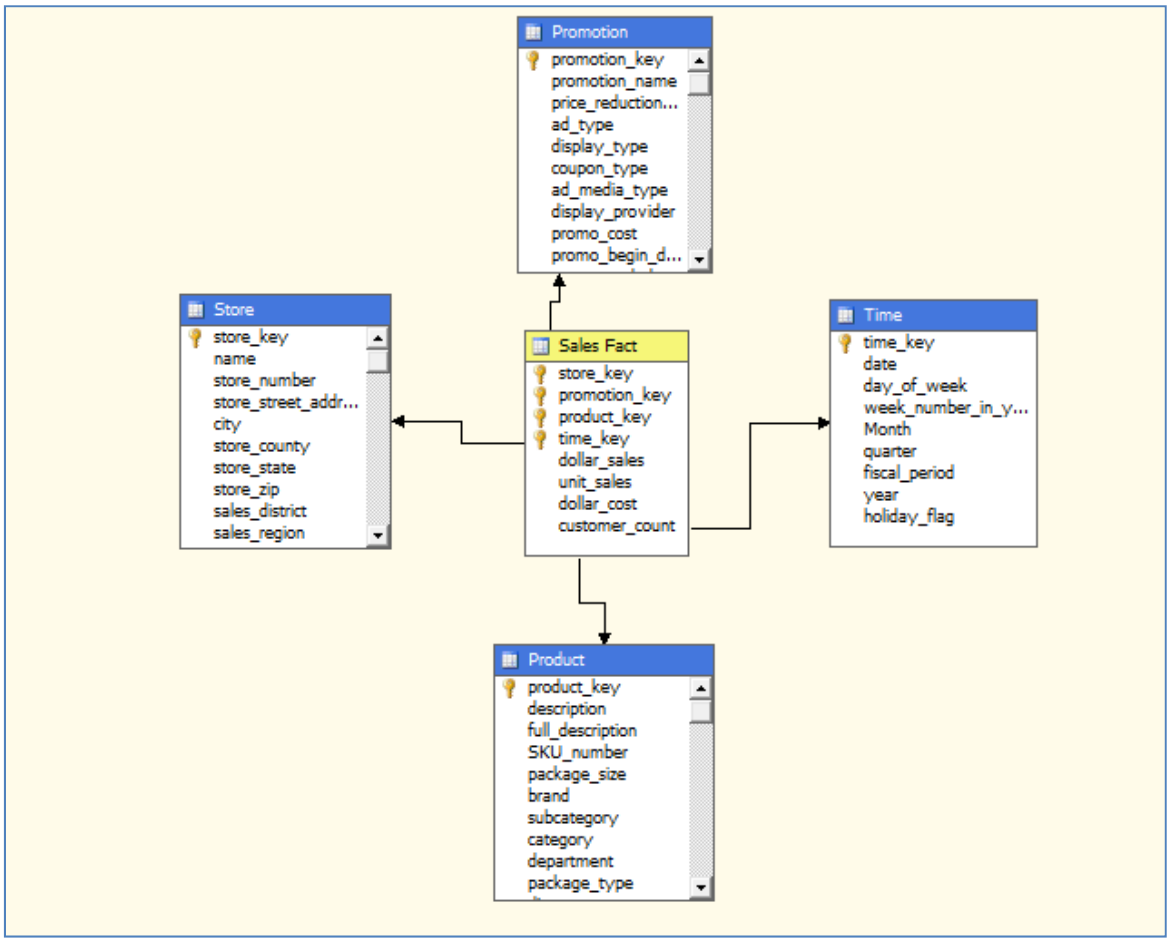


Figure 28 - Star Schema for Test Database

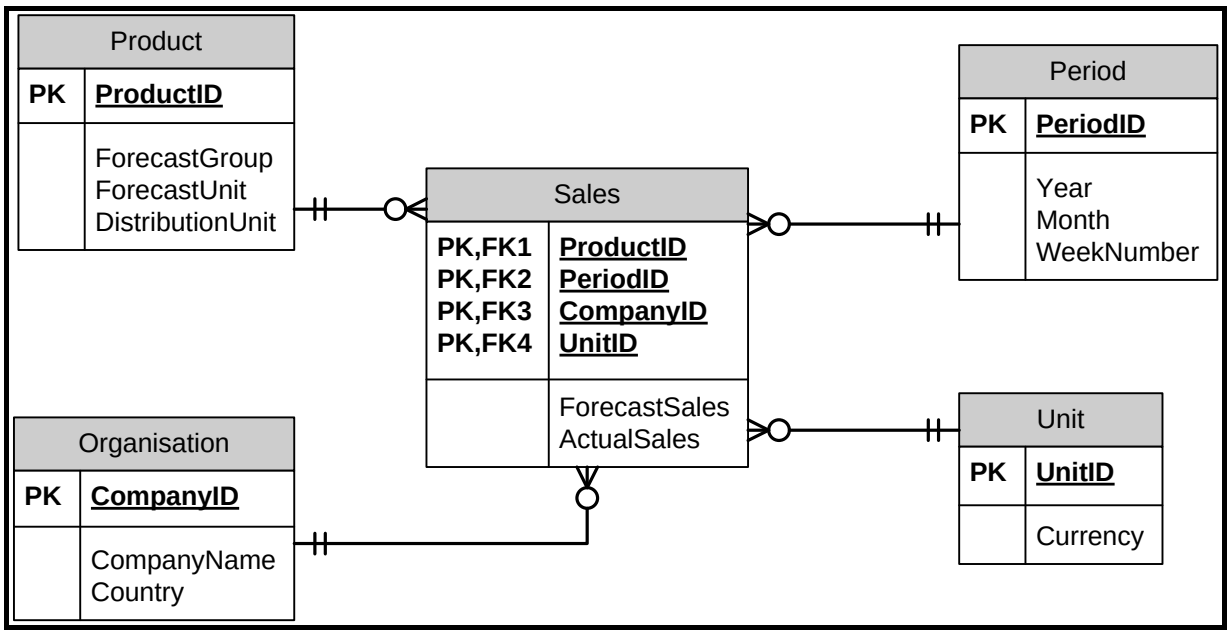


Figure 29 – Simplified Dimensional Model

As Unilever's DW/BI is implemented in SAP BW, SAP products are the preferred provider, so a natural choice of tool to investigate was SAP's BusinessObjects BI solutions - Crystal Reports 2008. The testing environment was using SQL Server, so Report Builder 2.0 for SQL Server was chosen as another BI tool so that it could be compared and contrasted with the features of Crystal Reports.

A 30-day trial version of Crystal Reports 2008 and Report Builder 2.0 was installed.

13. INVESTIGATION OF THIRD PARTY BI APPLICATIONS

Each of the BI features identified in the matrix columns in Table 4 were investigated in Crystal Reports and Report Builder. Firstly, the standard reporting features are discussed followed by the more advanced features associated with an OLAP cube and with Crystal Reports' OLAP Analyser.

The investigation was constrained by a 30-day software trial period, so although some of the features could not be reproduced it does not necessarily mean that they are not available, but may be more technically challenging to produce.

13.1. Standard Reporting Features

13.1.1. Drill-down Functionality in a Standard Report

One of the most important needs for the planning managers is to be presented with an overall summary picture of their data and to be able to drill down into areas they wish to look at in more detail.

An example of drilling down to detailed data in the S&OP Reports is to drill down from the summary figures in a forecast group to the last three year's forecast data for the forecast units belonging to the forecast group, and to drill down on one of the forecast units to see a graphical analysis of the data (see Figure 30).

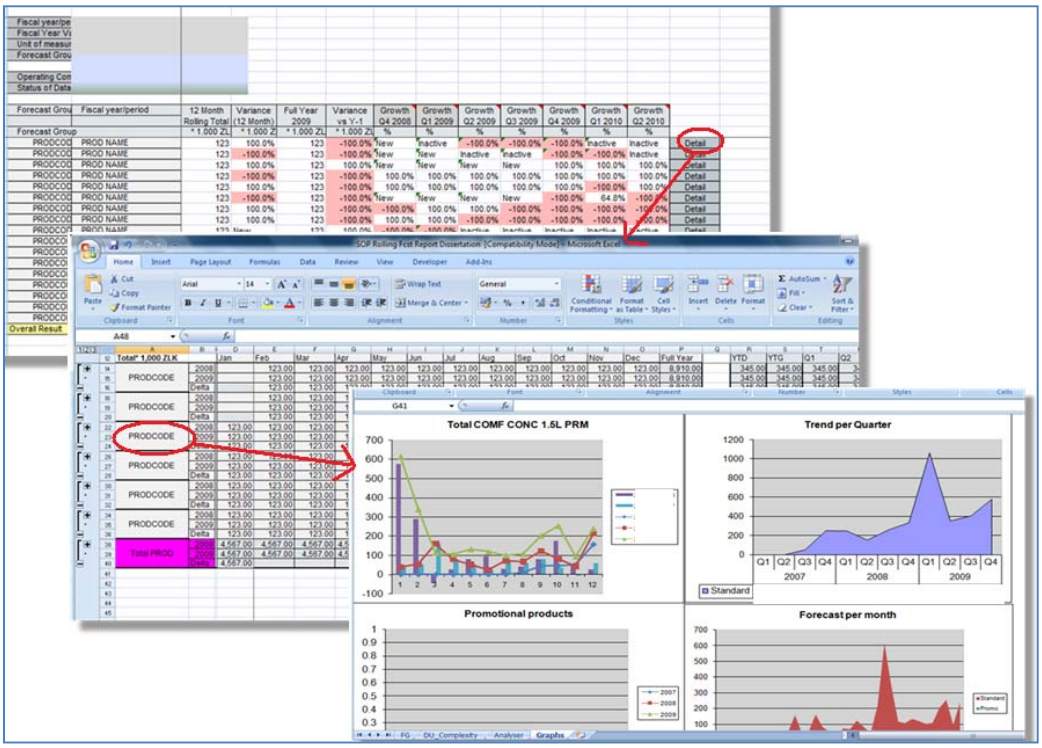


Figure 30 – S&OP Reports Drill-down to Graphs

The data in this report is based on a relational database view and the same functionality is reproduced in Crystal Reports, albeit much simplified, with the purpose of demonstrating the functionality rather than reproducing all the features of the S&OP Reports. Figure 31 shows the drill-down functionality from the product brand to more detailed information about the products belonging to the brand, and drilling on a particular product to show a graphical analysis of the data.

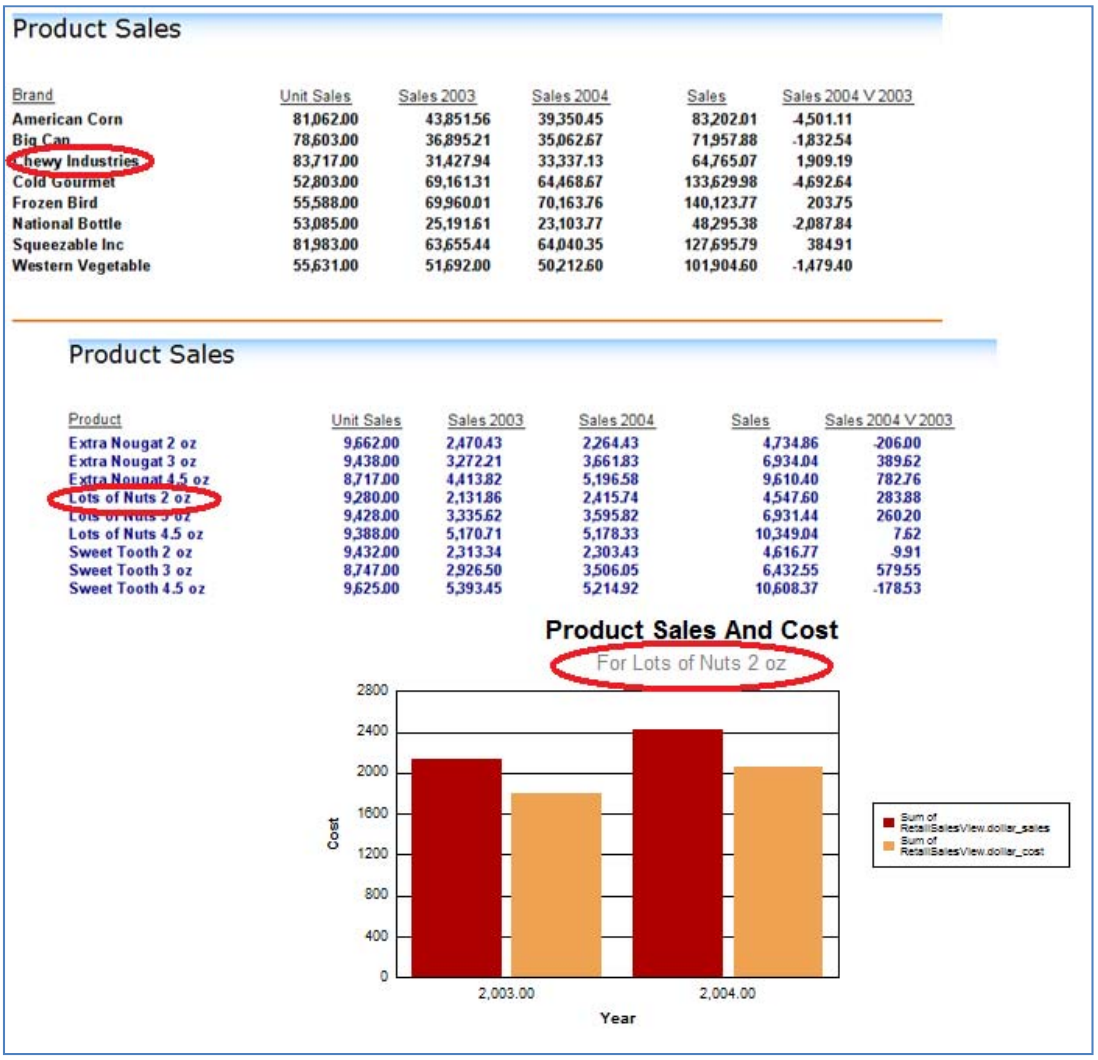


Figure 31 – Crystal Reports Drill-down to Graphs

The same functionality was difficult to display in Report Builder 2.0 without setting up a report server which is beyond the scope of this dissertation.

13.2. Parameters

Parameterised reports enable the user to vary the data or the behaviour of the report. When a parameterised report runs, the user is asked to select or input a value which will be used by the report. The S&OP Reports use parameters to enable users to vary the period of data to analyse e.g. 12 Month Rolling, Current Year and Next Year. Figure 32 shows how parameterised reports can be achieved in Crystal Reports. In this example, when the report is run, a pop-up box appears for the user to select the year they want to show in the report.

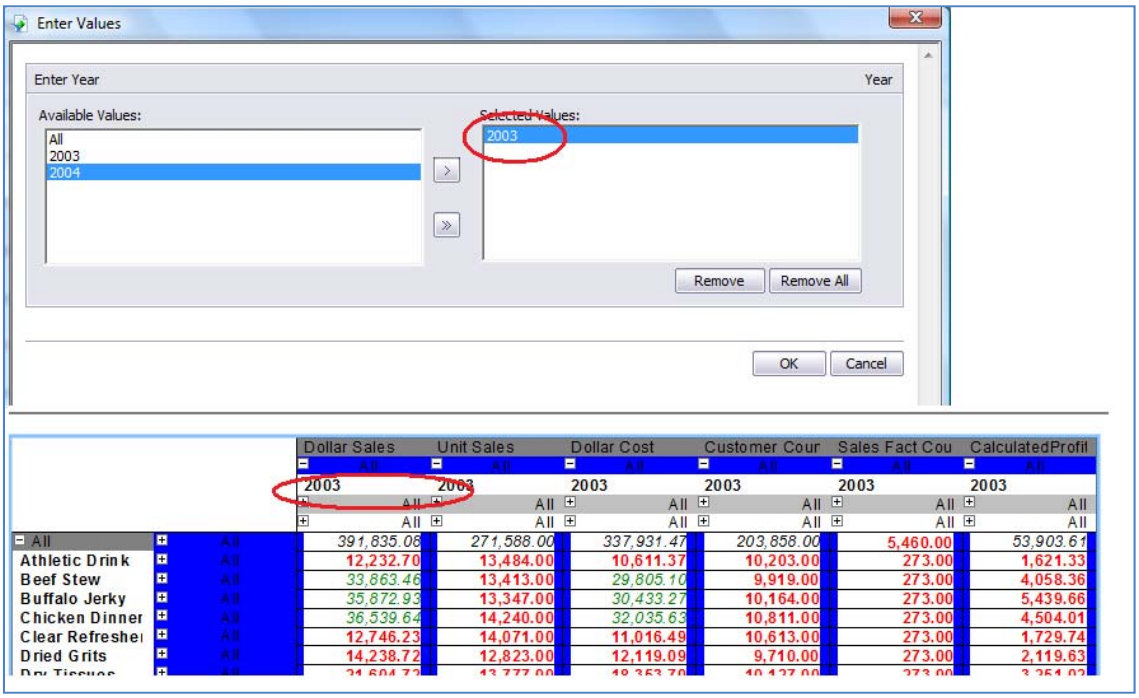


Figure 32 – Crystal Reports Parameters

The same functionality can be achieved in Report Builder, although in a less intuitive way, which involves knowledge of SQL queries to modify the data set to accept parameters (see Figure 33).

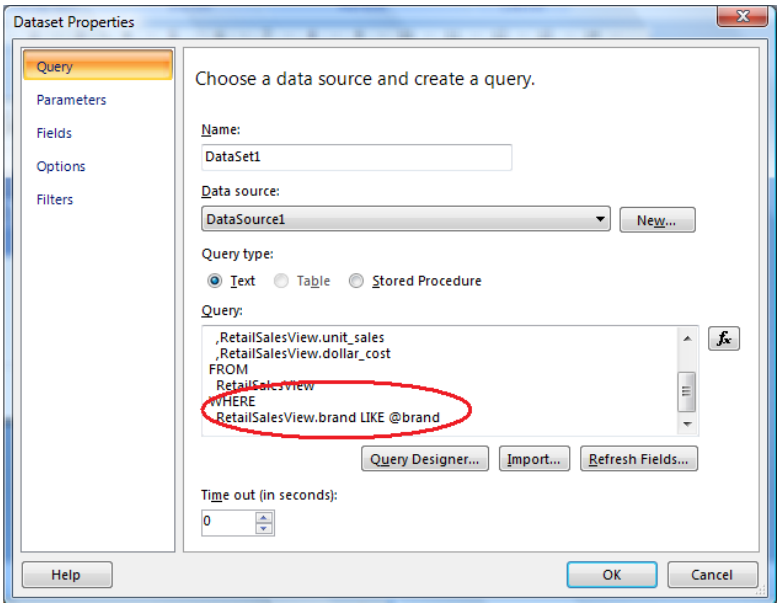


Figure 33 – Adding a Parameter to a Query

The parameter is then modified to accept a list of values (see Figure 34).

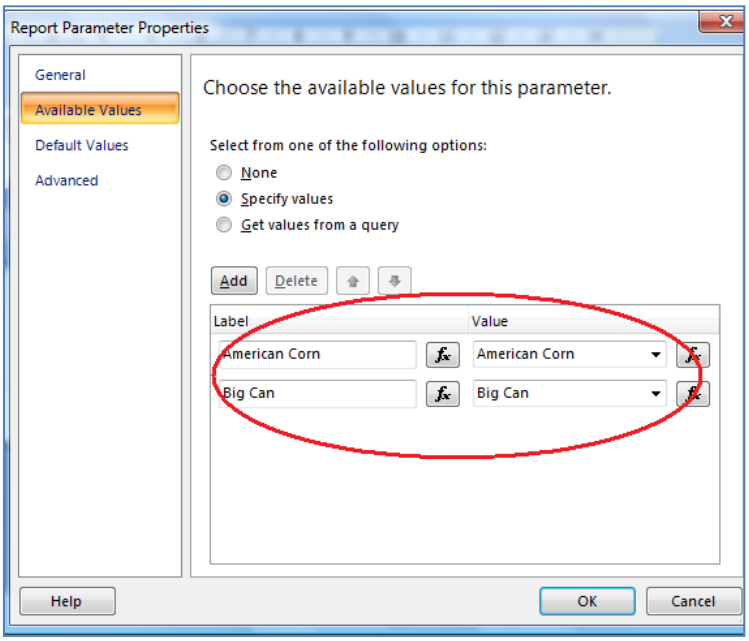


Figure 34 – Parameter Values

Figure 35 shows the report which has been run by selecting a parameter from the drop down box.

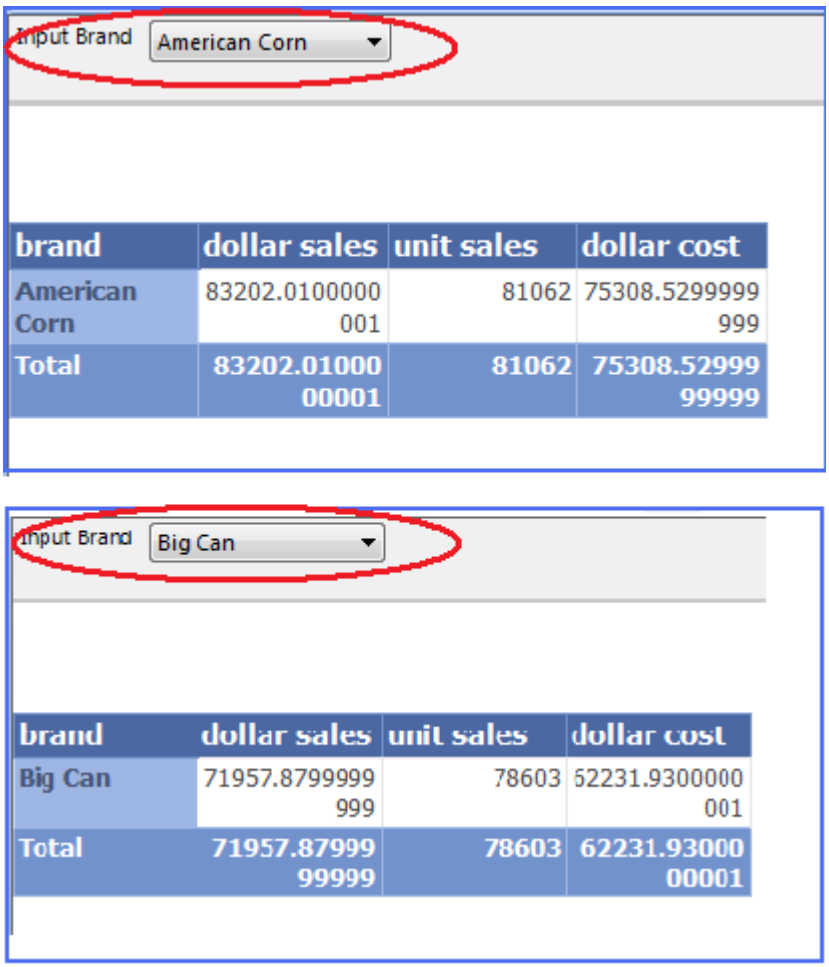


Figure 35 – Running a Parameterised Report

This two-step action appeared to add unnecessary complexity to adding parameters to a report.

13.3. Column and Row Calculations

Calculations on the results set returned from the InfoCube are applied to the S&OP Reports to present the information in a way that is informative to the planning managers. Figure 36 shows an example of the calculations that are made, such as 12 month rolling total, variance, full-year total and variance compared to last year.

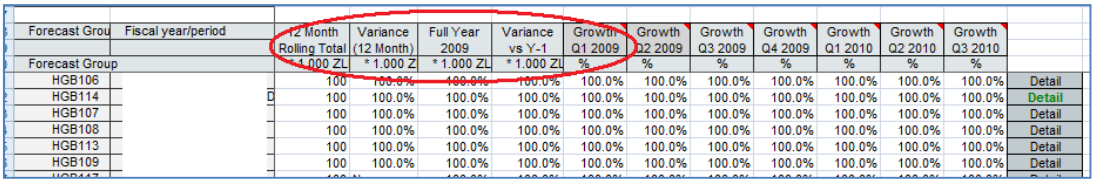


Figure 36 – S&OP Reports' Calculations

Custom calculations can be made in Crystal Reports either in the OLAP grid or in the report body. Figure 37 shows how a pop-up box helps the user to create a calculated column in an OLAP grid, circled on the right of the figure, by selecting the dimensions and the calculation to be performed.

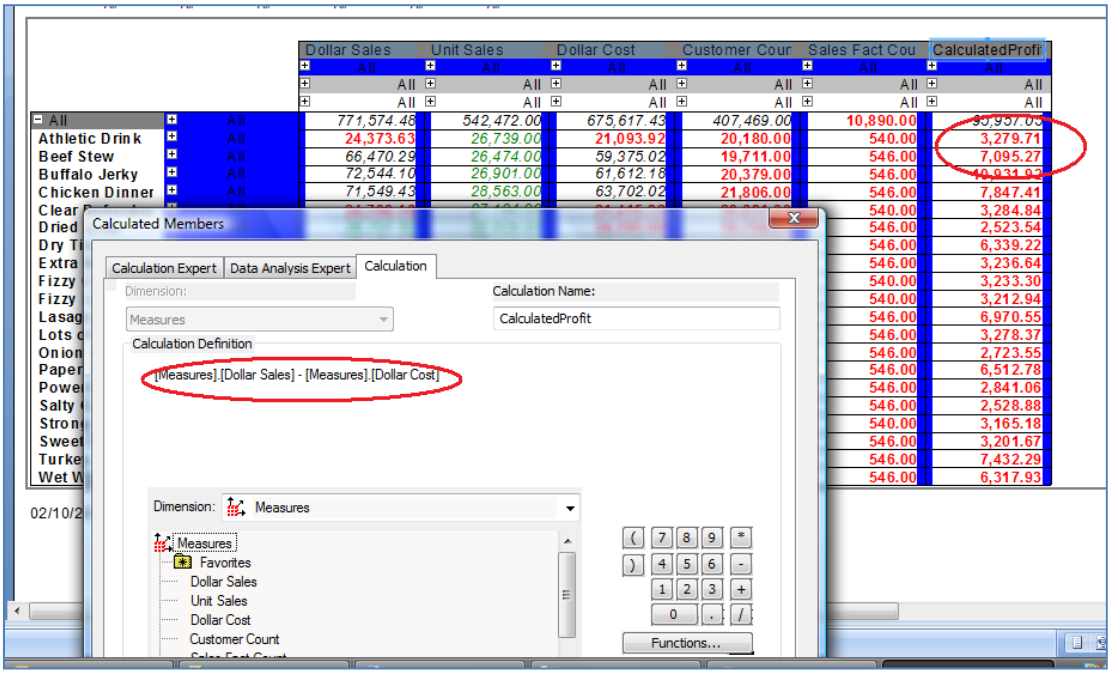


Figure 37 – Crystal Reports' OLAP Calculations

Calculations in the body of the report can be made by using the formula workshop. Figure 38 shows how a calculation is made to compare this year's sales with last year's to produce the 'Sales 2004 V 2003' column.

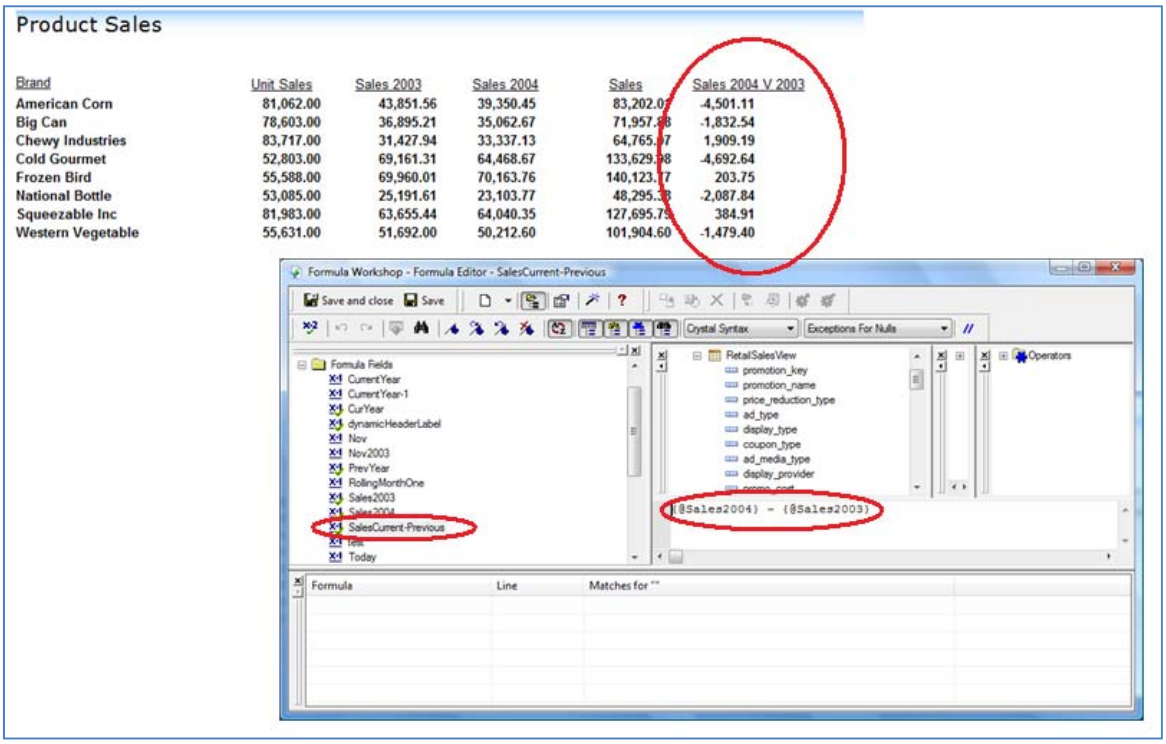


Figure 38 – Crystal Reports' Calculations Using the Formula Workshop

The functionality is reproduced in Report Builder and Figure 39 shows how the calculated field is added to the report by using a similar pop-up box to the one used in Crystal Reports.

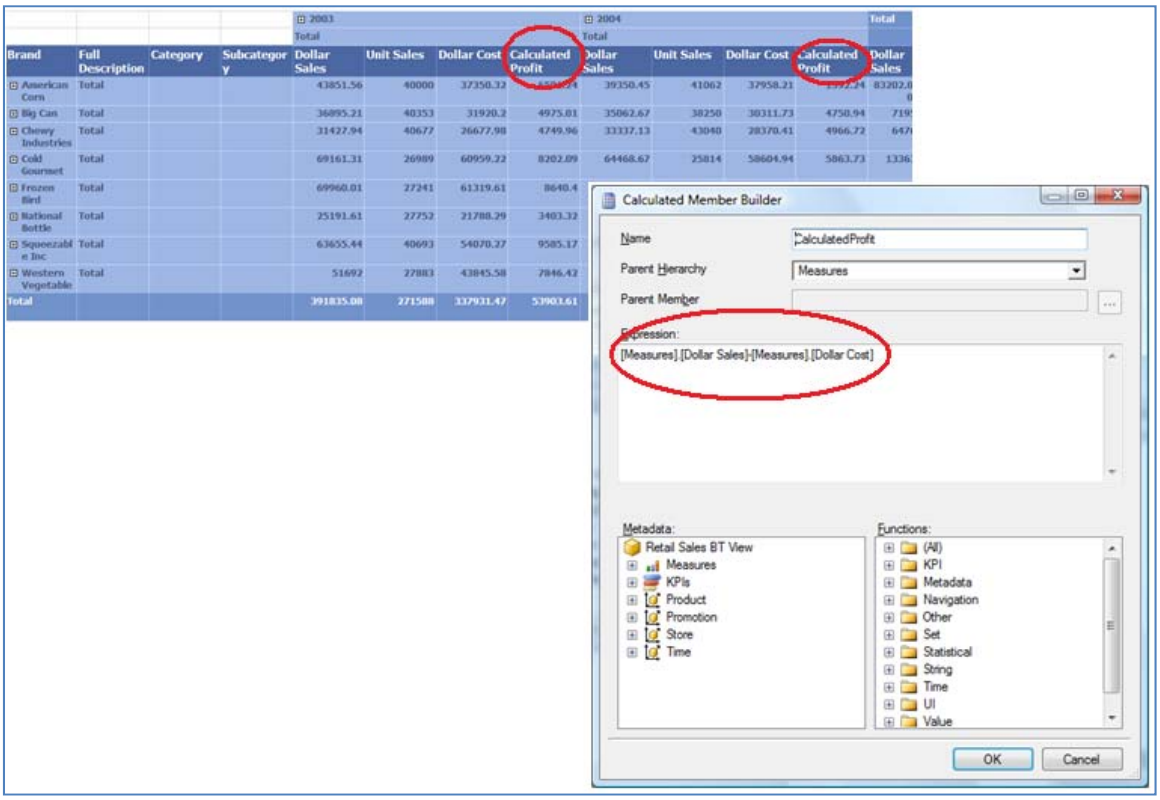


Figure 39 – Report Builder's Calculated Field

13.4. Exception Highlighting

Highlighting exceptions enhances the readability of a report. Exception highlighting enables users to specify their own parameters for highlighting values and how those values are to be displayed. The bespoke system changes the background colour for negative values. Figure 40 shows the same functionality in Crystal Reports by using the highlighting expert to change the background colour in this example to red, if the measure is less than 25,000.

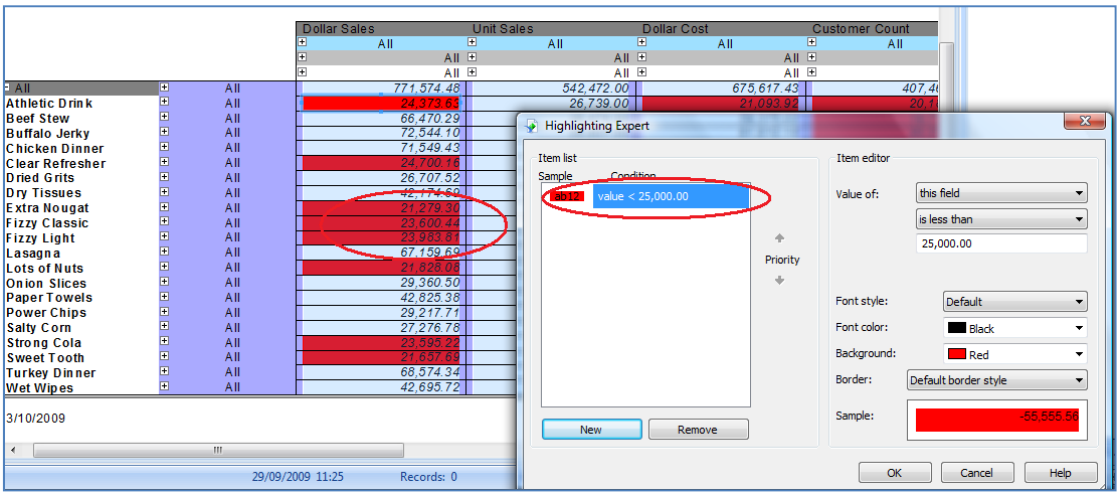


Figure 40 – Highlighting Expert

The same can be achieved in Report Builder by adding an expression to the background colour properties to change the background colour depending on a condition.

=Iif(Fields!Dollar_Sales.Value < 25000, "Red", "White")

This method is not as user friendly as the exception highlighting tool in Crystal Reports.

13.5. Qualitative Comments

Qualitative comments can offer extra information to communicate to the reader. Figure 41 shows how comments in the bespoke system are used to explain to the reader how figures are calculated.

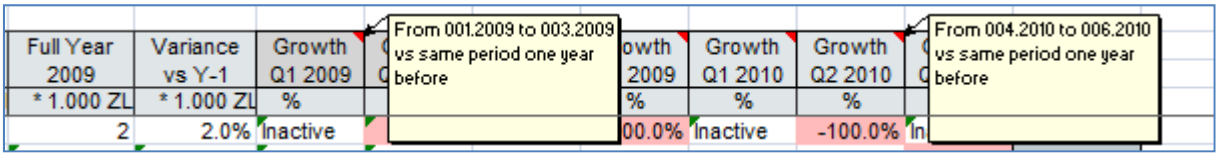


Figure 41 - S&OP Reports' Qualitative Comments

This feature could not be found in Crystal Reports or Report Builder.

13.6. Sorting

Sorting is achieved in the S&OP Reports in the application code e.g. forecast units sorted in order of volume at run-time, and by using the standard sorting facility available in Excel after the report has run. Sorting is achieved in Crystal Reports, either by selecting which fields to sort on when designing the report or by adding an interactive sort button to

rows or columns that allows users to sort the data after the report has run. Figure 42 shows an interactive sort button applied to the Brand column.

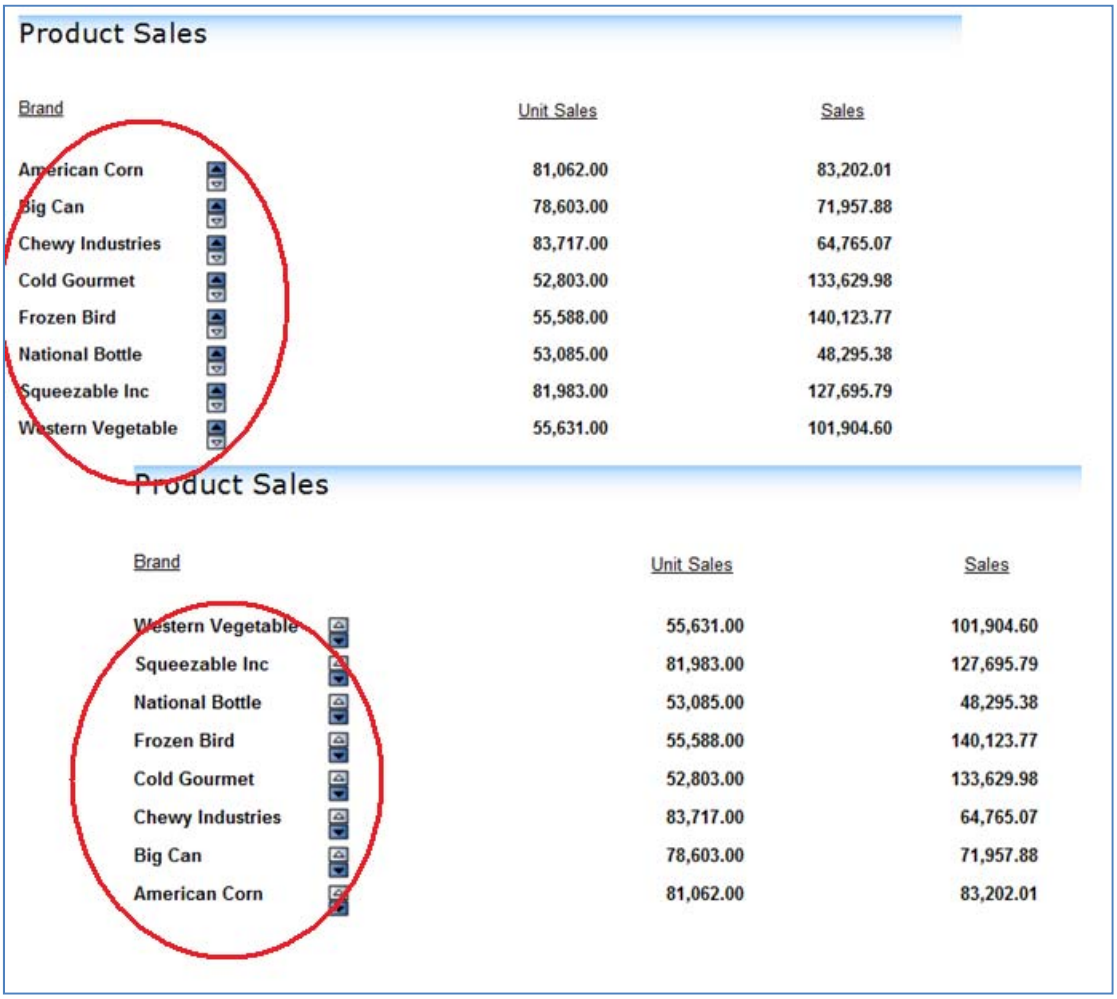


Figure 42 - Crystal Reports' Sorting Columns

13.7. Charts and Graphs

Charts and graphs provide the reader with a visual representation of the data that can make interpreting the data easier. The S&OP Reports contain a number of graphs. A selection of the graphs were chosen: plotting a moving average, showing trend lines, and showing a series as a different chart type e.g. show forecast and actual figures in a bar chart and line chart on the one chart. An attempt was made to reproduce these graphs in Crystal Reports and Report Builder. Figure 43 shows a bar chart of weekly sales and weekly costs with the moving average plotted as lines created in Crystal Reports. The same is reproduced by Report Builder in Figure 44.

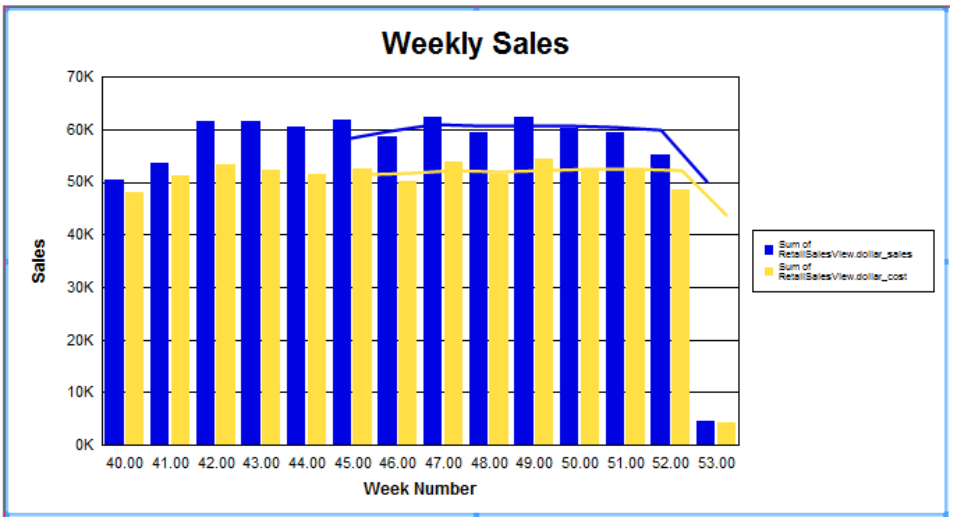


Figure 43 - Crystal Reports' Moving Average Graph

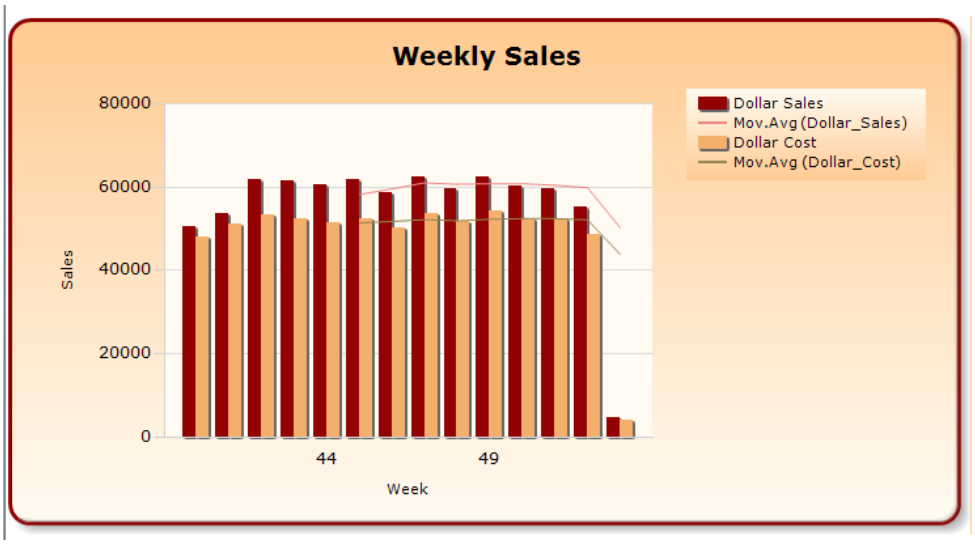


Figure 44 - Report Builder's Moving Average Graph

Figure 45 shows sales and cost by brand with trend lines created in Crystal Reports. An equivalent function to plot a linear trend line could not be found in Report Builder.

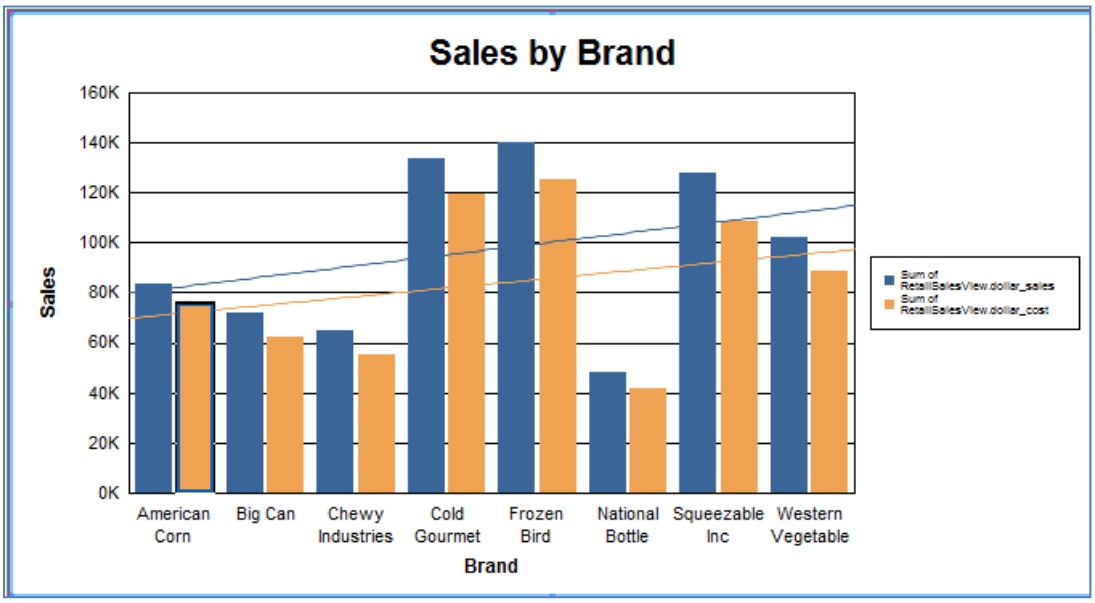


Figure 45 - Crystal Reports' Trend Lines Graph

Finally, Figure 46 shows a bar chart and a line chart combined onto one graph created in Crystal Reports and Figure 47 shows the same in Report Builder.

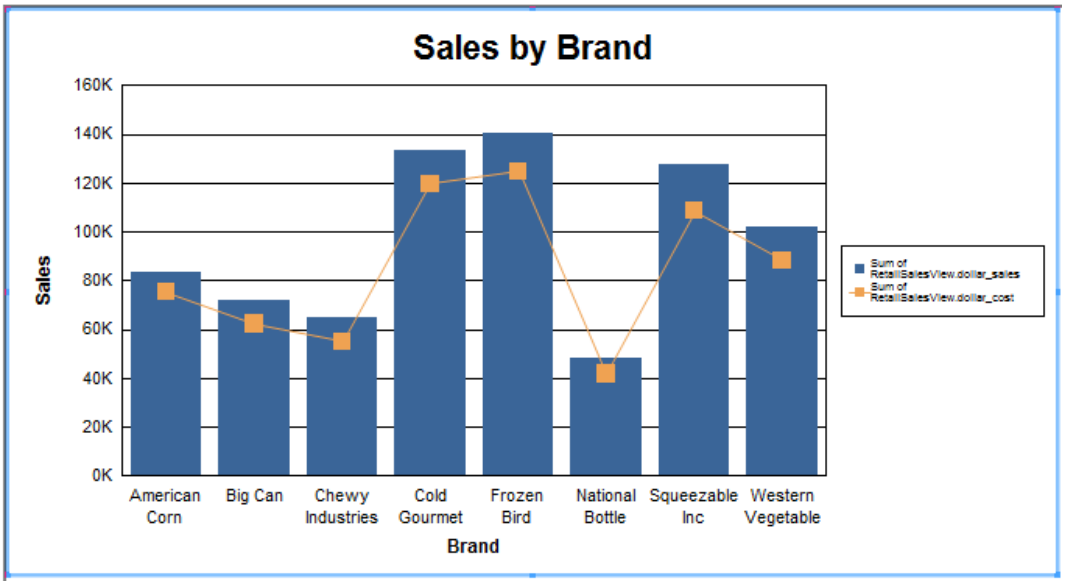


Figure 46 - Crystal Reports' Combination Charts

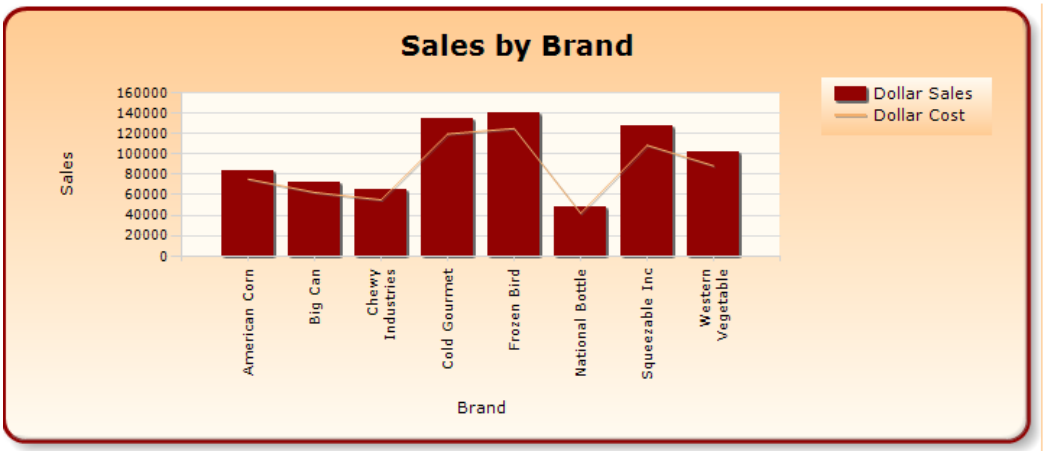


Figure 47 - Report Builder's Combination Charts

13.8. Grouping and Sub Totals

Grouping and sub totals are one of the fundamental functionalities of any reporting software and are used throughout the S&OP Reports. Figure 48 shows a report created in Crystal Reports grouped by brand, with a sub total for each brand and the grand total and the same is shown in Figure 49 for Report Builder.

Product Sales

Brand	Sales	Unit Sales
American Corn		
Dried Grits 2 oz	5,474.98	8,470.00
Dried Grits 3 oz	8,216.81	8,476.00
Dried Grits 4.5 oz	13,015.73	8,883.00
Power Chips 3 oz	5,977.47	9,119.00
Power Chips 4.5 oz	9,215.10	9,516.00
Power Chips 6.7 oz	14,025.14	9,598.00
Salty Corn 2 oz	6,173.91	9,632.00
Salty Corn 3 oz	8,645.71	8,890.00
Salty Corn 4.5 oz	12,457.16	8,478.00
Sub Total	83,202.01	81,062.00
Big Can		
Athletic Drink 13.5 oz	11,265.06	8,643.00
Athletic Drink 6 oz	5,278.46	9,081.00
Athletic Drink 9 oz	7,830.11	9,015.00
Fizzy Classic 13.5 oz	10,877.09	8,344.00
Fizzy Classic 6 oz	4,881.74	8,416.00
Fizzy Classic 9 oz	7,841.61	8,991.00
Fizzy Light 13.5 oz	11,458.78	8,782.00
Fizzy Light 6 oz	5,015.35	8,669.00
Fizzy Light 9 oz	7,509.68	8,662.00
Sub Total	71,957.88	78,603.00
Grand Total	771,574.48	542,472.00

Figure 48 - Crystal Reports' Grouping and Sub Totals

Product Sales

brand	full description	Total	2003	2004
American Corn	Dried Grits 2 oz	5474.98	2736.75	2738.23
	Dried Grits 3 oz	8216.81	4511.5	3705.31
	Dried Grits 4.5 oz	13015.73	6990.47	6025.26
	Power Chips 3 oz	5977.47	3193.18	2784.29
	Power Chips 4.5 oz	9215.1	4878.98	4336.12
	Power Chips 6.7 oz	14025.14	7482.73	6542.41
	Salty Corn 2 oz	6173.91	3160.16	3013.75
	Salty Corn 3 oz	8645.71	4372.49	4273.22
	Salty Corn 4.5 oz	12457.16	6525.3	5931.86
	Sub Total	83202.0100000001	43851.56	39350.45
Big Can	Athletic Drink 13.5 oz	11265.06	5684.92	5580.14
	Athletic Drink 6 oz	5278.46	2766.72	2511.74
	Athletic Drink 9 oz	7830.11	3781.06	4049.05
	Fizzy Classic 13.5 oz	10877.09	5566.41	5310.68
	Fizzy Classic 6 oz	4881.74	2612.65	2269.09
	Fizzy Classic 9 oz	7841.61	3831.3	4010.31
	Fizzy Light 13.5 oz	11458.78	5957.01	5501.77
	Fizzy Light 6 oz	5015.35	2436.4	2578.95
	Fizzy Light 9 oz	7509.68	4258.74	3250.94
	Sub Total	71957.8799999999	36895.21	35062.67

Figure 49 - Report Builder's Grouping and Sub Totals

13.9. Dashboards

Dashboards provide managers with a visual representation of key performance indicators. Various graphs and dials, much like the dials on a car dashboard, can be combined into a single view to show high-level summary data e.g. total orders placed, total orders delivered on time, total non-damaged orders. Figure 50 shows an example in Crystal Reports of including dials in a report showing the forecast accuracy figures for a Brand. If a dial was pointing to a red region, the user may want to find out the reason for high forecasting inaccuracy for a particular brand.

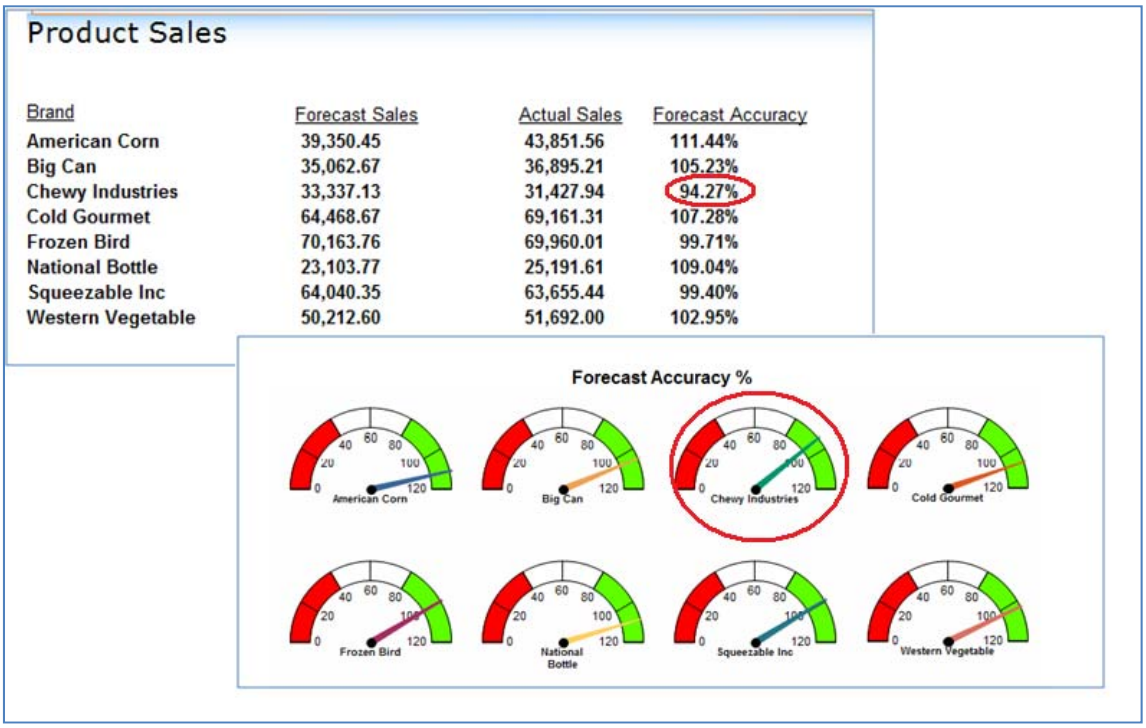


Figure 50 - Crystal Reports' Dials

Although Report Builder does offer the features of dials and gauges, it was not possible in the time available to reproduce the gauges for brand groupings.

13.10. OLAP Cube

More advanced BI features can be found when connecting to an OLAP cube.

13.10.1. Drill-down OLAP Cube

The S&OP Reports present the data with drillable rows and columns. The planning manager can drill down the product hierarchy circled on the left of Figure 51, and the measures (e.g. Contribution to Bias) across the top can be drilled down by month and week.

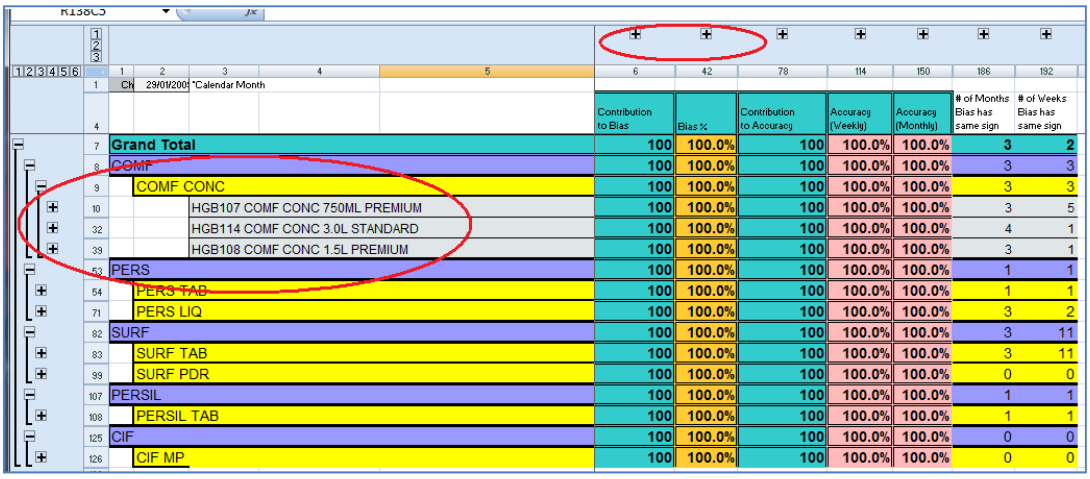


Figure 51 - S&OP Reports' Drill-down

Similar functionality is reproduced by connecting to a cube using Crystal Reports; an OLAP grid embedded into a report has drill-down functionality for rows and columns. Based on the test data, Figure 52 shows summary data which is expandable in much the same way as the S&OP Reports.

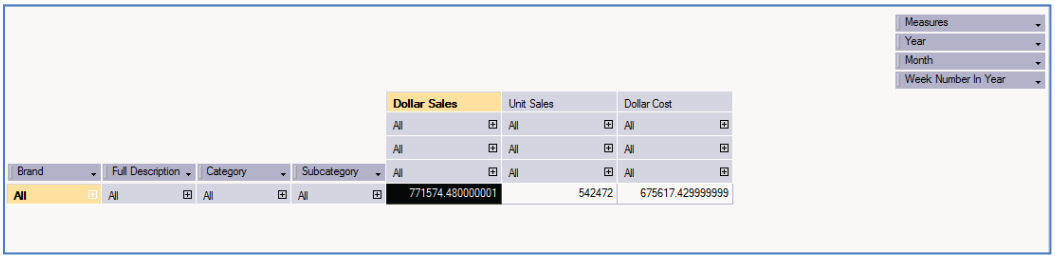


Figure 52 – Crystal Reports' OLAP Grid Summary Data

From the total summary, a user can click on the plus sign to drill down into a Brand's detail (circled in Figure 53), and then again into the products that belong to the Brand (circled in Figure 54).

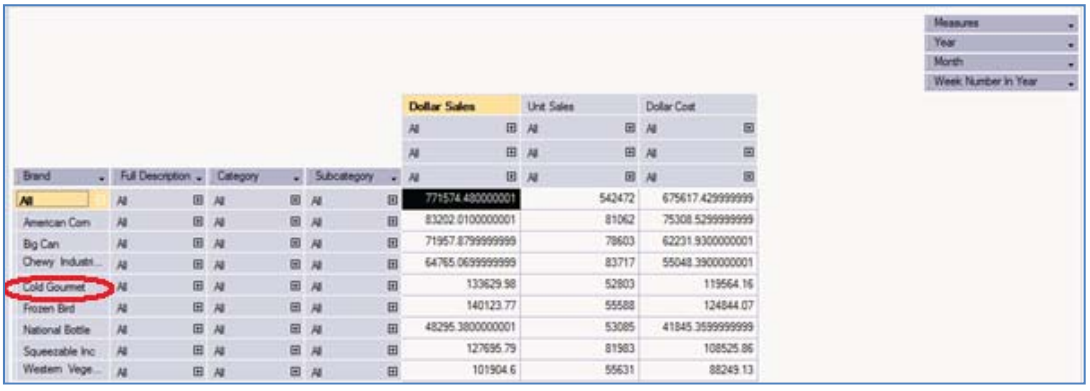
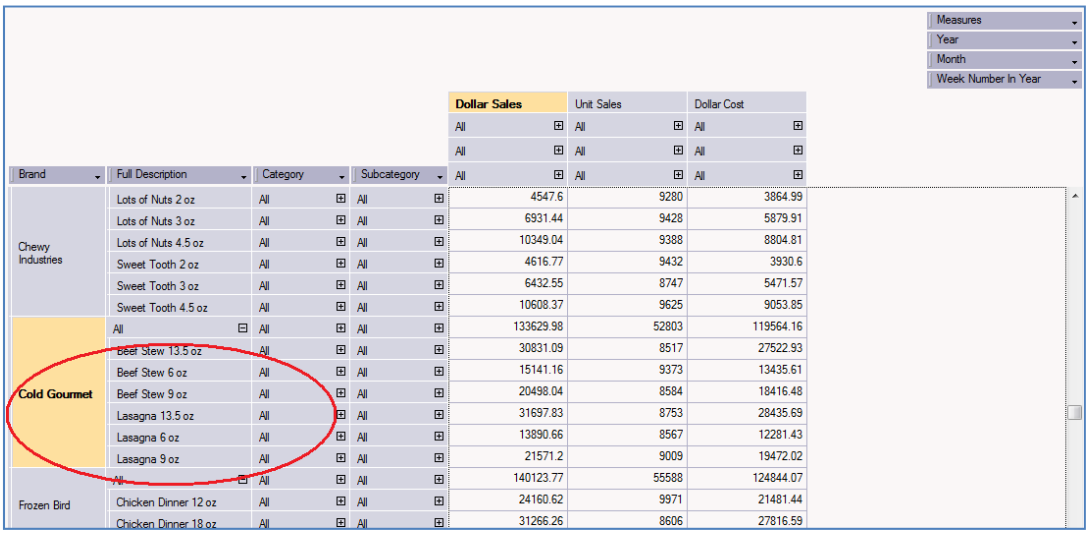


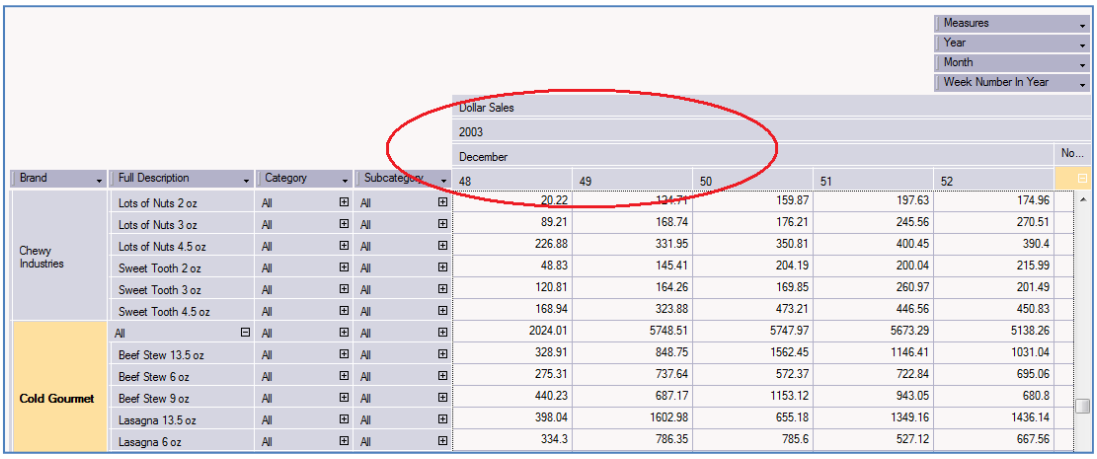
Figure 53 – Crystal Reports' Drill-down into Brand Data



Measures			
Year			
Month			
Week Number In Year			
	Dollar Sales	Unit Sales	Dollar Cost
	All	All	All
	All	All	All
Brand / Full Description / Category / Subcategory	All	All	All
Chewy Industries / Lots of Nuts 2 oz / All / All	4547.6	9280	3864.99
Lots of Nuts 3 oz / All / All	6931.44	9428	5879.91
Lots of Nuts 4.5 oz / All / All	10349.04	9388	8804.81
Sweet Tooth 2 oz / All / All	4616.77	9432	3930.6
Sweet Tooth 3 oz / All / All	6432.55	8747	5471.57
Sweet Tooth 4.5 oz / All / All	10608.37	9625	9053.85
Cold Gourmet / All / All / All	133629.98	52803	119564.16
Beef Stew 13.5 oz / All / All	30831.09	8517	27522.93
Beef Stew 6 oz / All / All	15141.16	9373	13435.61
Beef Stew 9 oz / All / All	20498.04	8584	18416.48
Lasagna 13.5 oz / All / All	31697.83	8753	28435.69
Lasagna 6 oz / All / All	13890.66	8567	12281.43
Lasagna 9 oz / All / All	21571.2	9009	19472.02
Frozen Bird / All / All / All	140123.77	55588	124844.07
Chicken Dinner 12 oz / All / All	24160.62	9971	21481.44
Chicken Dinner 18 oz / All / All	31266.26	8606	27816.59

Figure 54 – Crystal Reports' Drill-down from Brand to Product Data

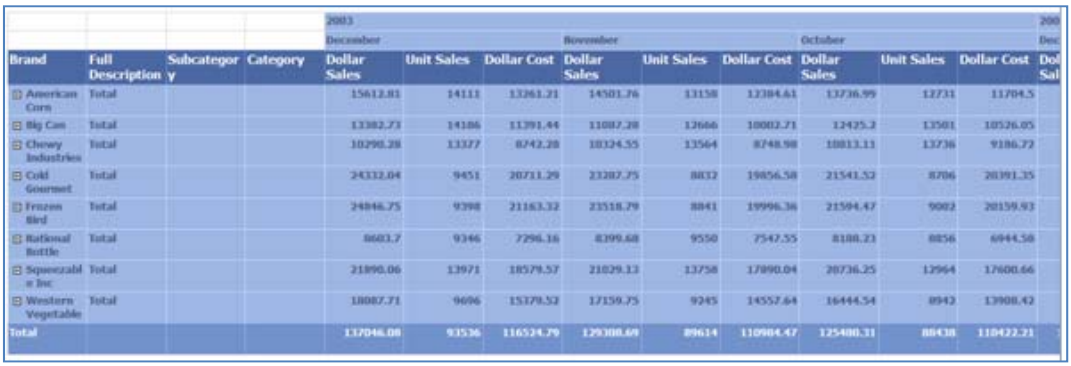
The columns can also be drilled down from measure e.g. dollar sales, to the year, month and weekly detail that make up the total figures (circled in Figure 55).



Measures					
Year					
Month					
Week Number In Year					
	Dollar Sales				
	2003				
	December				No...
Brand / Full Description / Category / Subcategory	48	49	50	51	52
Chewy Industries / Lots of Nuts 2 oz / All / All	20.22	134.71	159.87	197.63	174.96
Lots of Nuts 3 oz / All / All	89.21	168.74	176.21	245.56	270.51
Lots of Nuts 4.5 oz / All / All	226.88	331.95	350.81	400.45	390.4
Sweet Tooth 2 oz / All / All	48.83	145.41	204.19	200.04	215.99
Sweet Tooth 3 oz / All / All	120.81	164.26	169.85	260.97	201.49
Sweet Tooth 4.5 oz / All / All	168.94	323.88	473.21	446.56	450.83
Cold Gourmet / All / All / All	2024.01	5748.51	5747.97	5673.29	5138.26
Beef Stew 13.5 oz / All / All	328.91	848.75	1562.45	1146.41	1031.04
Beef Stew 6 oz / All / All	275.31	737.64	572.37	722.84	695.06
Beef Stew 9 oz / All / All	440.23	687.17	1153.12	943.05	680.8
Lasagna 13.5 oz / All / All	398.04	1602.98	655.18	1349.16	1436.14
Lasagna 6 oz / All / All	334.3	786.35	785.6	527.12	667.56

Figure 55 – Crystal Reports' Column Drill-down

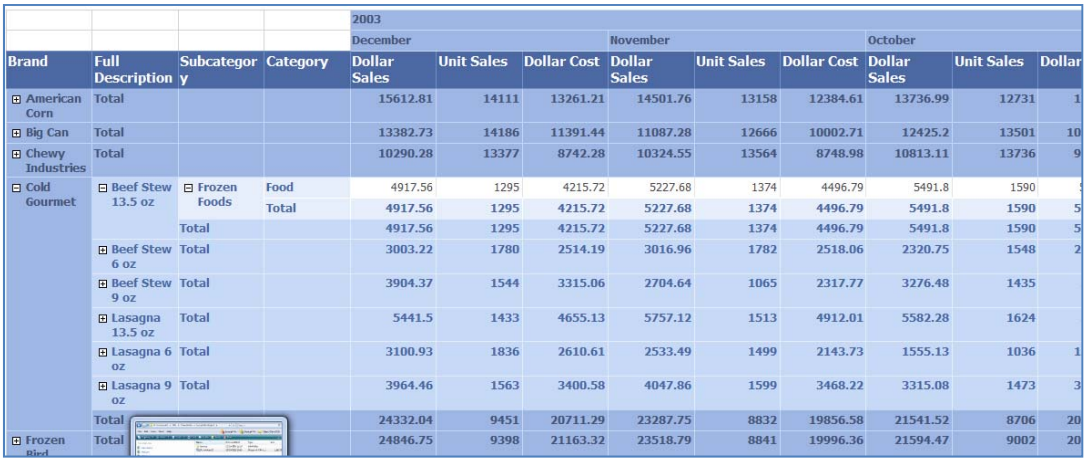
The same was attempted in Report Builder 2.0 using the same OLAP cube but there were limitations that prevented the drill-down functionality. It was not possible to include the measures in the column groups or to add the drill-down functionality to the columns, only to the rows. Note how the plus sign to expand the columns in Figure 56 is absent.



				2003									200
				December			November			October			Dec
Brand	Full Description	Subcategory	Category	Dollar Sales	Unit Sales	Dollar Cost	Dollar Sales	Unit Sales	Dollar Cost	Dollar Sales	Unit Sales	Dollar Cost	Dol Sal
American Corn	Total			15612.81	14111	13261.21	14501.76	13158	12384.61	13736.99	12731	11704.5	
Big Can	Total			13382.73	14186	11391.44	11087.28	12666	10002.71	12425.2	13501	10526.05	
Chewy Industries	Total			10290.28	13377	8742.28	10324.55	13564	8748.98	10813.11	13736	9186.72	
Cold Gourmet	Total			24332.04	9451	20711.29	23287.75	8832	19856.58	21541.52	8706	20391.35	
Frozen Bird	Total			24846.75	9398	21163.32	23518.79	8841	19996.36	21594.47	9002	20159.93	
Rational Bottle	Total			8603.7	9346	7296.16	8399.68	9550	7547.55	8188.23	8856	6944.58	
Squeezable Inc	Total			21890.06	13971	18579.57	21029.13	13758	17890.04	20736.25	12964	17600.66	
Western Vegetable	Total			18087.71	9696	15379.52	17159.75	9245	14557.64	16444.54	8942	13908.42	
Total				137046.08	93536	116524.79	129308.69	89614	110984.47	125480.31	88438	110422.21	

Figure 56 - Report Builder's OLAP Grid Summary Data

Figure 57 shows the result when drilling down from the Brand 'Cold Gourmet' to product detail.



				2003								
				December			November			October		
Brand	Full Description	Subcategory	Category	Dollar Sales	Unit Sales	Dollar Cost	Dollar Sales	Unit Sales	Dollar Cost	Dollar Sales	Unit Sales	Dollar
American Corn	Total			15612.81	14111	13261.21	14501.76	13158	12384.61	13736.99	12731	1
Big Can	Total			13382.73	14186	11391.44	11087.28	12666	10002.71	12425.2	13501	10
Chewy Industries	Total			10290.28	13377	8742.28	10324.55	13564	8748.98	10813.11	13736	9
Cold Gourmet	Beef Stew 13.5 oz	Frozen Foods	Food	4917.56	1295	4215.72	5227.68	1374	4496.79	5491.8	1590	
			Total	4917.56	1295	4215.72	5227.68	1374	4496.79	5491.8	1590	5
		Total		4917.56	1295	4215.72	5227.68	1374	4496.79	5491.8	1590	5
	Beef Stew 6 oz	Total		3003.22	1780	2514.19	3016.96	1782	2518.06	2320.75	1548	2
	Beef Stew 9 oz	Total		3904.37	1544	3315.06	2704.64	1065	2317.77	3276.48	1435	
	Lasagna 13.5 oz	Total		5441.5	1433	4655.13	5757.12	1513	4912.01	5582.28	1624	
	Lasagna 6 oz	Total		3100.93	1836	2610.61	2533.49	1499	2143.73	1555.13	1036	1
	Lasagna 9 oz	Total		3964.46	1563	3400.58	4047.86	1599	3468.22	3315.08	1473	3
	Total			24332.04	9451	20711.29	23287.75	8832	19856.58	21541.52	8706	20
Frozen Bird	Total			24846.75	9398	21163.32	23518.79	8841	19996.36	21594.47	9002	20

Figure 57 - Report Builder's Drill-down from Brand to Product Detail

13.11. Pivot Results

The ability to pivot the results is a feature that allows the values that are shown on the rows and columns to be interchanged. The values on the rows are moved to the columns, and the values on the columns are moved to the rows. Figure 58 shows this feature in Crystal Reports, note that Brand is moved from the rows to the columns.

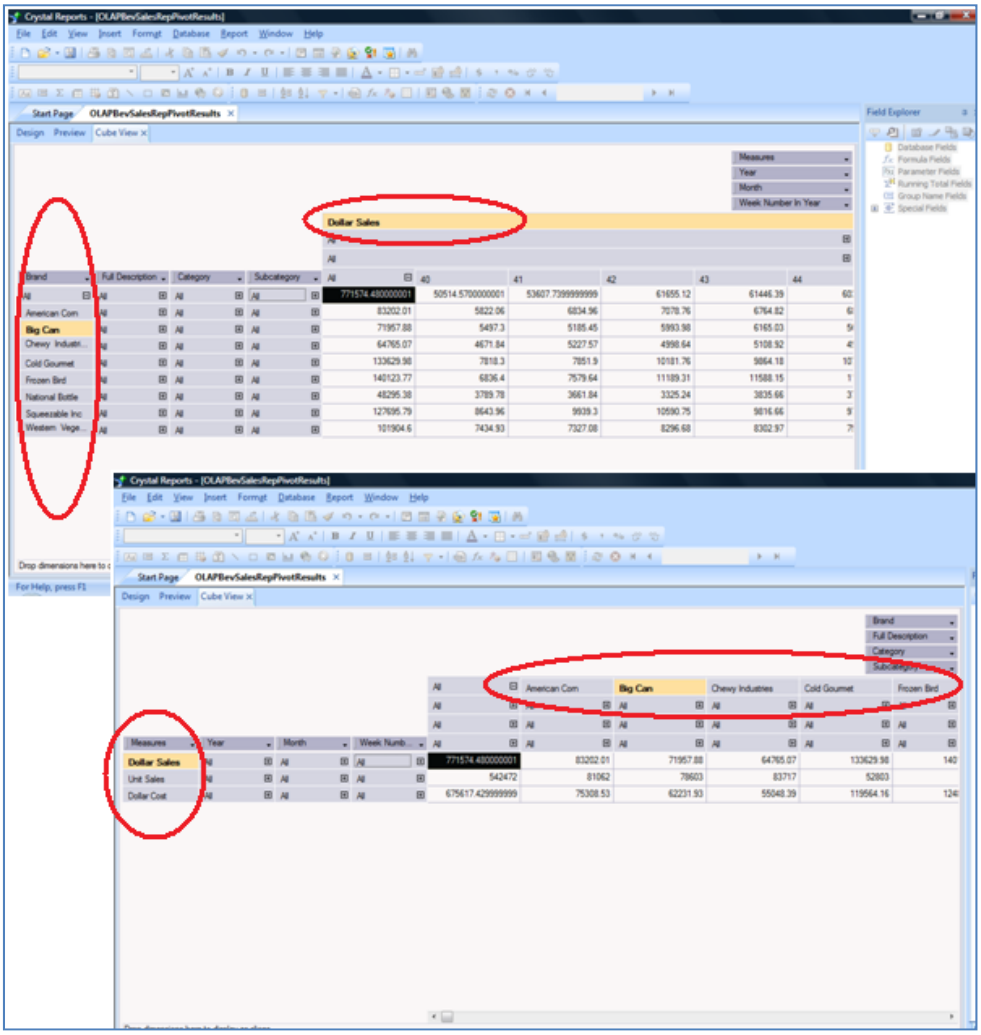


Figure 58 - Crystal Reports' Pivot Results

Report Builder does not appear to offer report interaction other than parameters and drill-down, therefore it was not possible to pivot results data. The only way to achieve this appeared to be to swap the columns and rows in the report design.

13.12. OLAP Analyser

Crystal Reports provides the OLAP Analyser, which allows users to interact with the data, with drill-down, drill-through and the ability to slice, dice, swap, and analyse the data. (Peck 2003, p. 523).

Although managers are only usually interested in drilling down one or two levels of data, sometimes they find it useful to drill-through the figures in the report to view the lowest detailed data behind the figures. Drill-through is available in Crystal Reports 2008 from

the OLAP Analyser (see Figure 59). Drill-through functionality is possible in Report Builder 2.0 if the reports are published on a report server but this was beyond the scope of this dissertation.

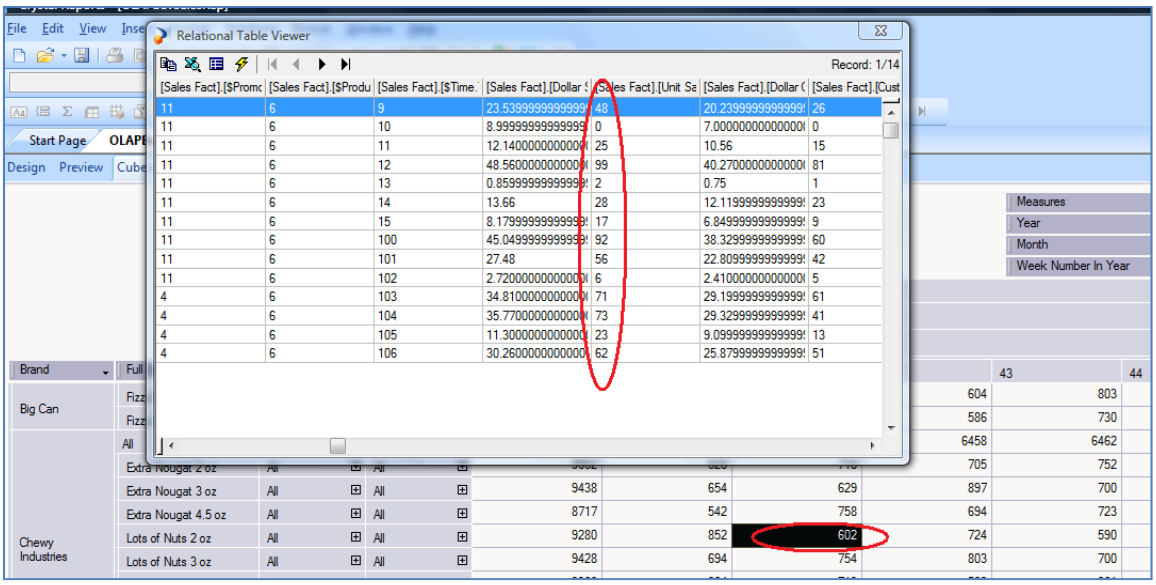


Figure 59 - Crystal Reports' 2008 Drill-through Functionality

Figure 60 shows the dimensions and measures which can be dragged down into the report pane to view slices and dices of the data.

Figure 60 - Crystal Reports' OLAP Analyser

13.13. Report Publishing

The S&OP Reports are delivered to users via a secure area. The reports developed by third party tools can be delivered through various mechanisms: they can be emailed or posted to a shared folder on the network; rendered to a range of formats such as HTML, PDF, CSV,

XML, and Image (TIFF) as well as Microsoft Office products such as Word, PowerPoint and Excel; delivered via subscriptions; viewed by users via a report portal or a web portal; or embedded into applications.

Both the third party vendors explored in the case study provide interfaces to support the secure delivery and exploration of reports. It is beyond the scope of this report to investigate the different interfaces.

13.14. User Access

Different levels of role-based access are provided for the S&OP Reports and to the queries in the InfoCube. Crystal Reports server, one of the interfaces for publishing reports developed in Crystal Reports offers robust security options for user, group, object, and folder levels to give the right people access to the right information at the right time. Likewise, Reporting Services for publishing reports developed in Report Builder offer role-based security to secure access to reports, folders, resources and shared data sources.

14. CASE STUDY DISCUSSION

At the beginning of this research it was asked whether third party BI tools could support the reporting needs of the planning group or whether they are so specific that a bespoke solution is the best option and thus reliance on IT departments is still necessary to support the delivery of business intelligence.

The investigations have shown that it is possible to develop most of the BI features identified in the matrix in Table 4. The ability to switch between showing the percentage or the absolute value could not easily be achieved. Likewise a feature to add qualitative comments to a report could not be found. The exception highlighting tool is very effective at changing formatting to highlight a value but it cannot be used to add text to a cell depending on a value. It should be noted that this does not mean that it is not possible to add these requirements, it just implies that they could not be easily added during the time frame of the case study. Adding calculations to reports ranged from being easy to implement to being rather more complex.

Other than these exceptions the other features were very easy to implement, particularly the charts and graphs. The user interface for Crystal Reports is much richer than the Report Builder interface. Combined with the added functionality of Crystal Reports' OLAP Analyser, it provides a simple analysis tool to view the data interactively. This would provide

the planning managers with the ability to interact with their data, and to produce the printed reports and graphs needed for their forecasting meetings.

15. DISCUSSION AND CONCLUSION

This research began by looking briefly at the history of DW/BI systems which have evolved considerably over the past decade. The discussion continued by describing a generic approach to developing a system presented within a structured framework based on a combination of the Zachman Framework and Kimball's lifecycle approach. It went on to identify and analyse the users of a DW/BI and to discuss the types of applications that support their needs.

The main findings of the research were that the needs of the BI user are of upmost importance when it comes to developing a DW/BI system and that these should be addressed at the requirements stage and as a parallel activity that runs alongside the back room development tracks. Another finding was that BI applications should be developed by front room staff who are more business orientated rather that technical back room staff. This suggests that flexible and intuitive user interfaces should be selected to support them. Furthermore, it was found that the needs of the BI application users can be analysed by grouping them into one of five classifications of user – Tourists, Farmers, Explorers, Miners and Operators and that different user interfaces are needed to support their needs.

Part Two, was a case study of the consumer brands organisation, Unilever and their implementation of a bespoke BI application which connects to data in their SAP business warehouse and is used to support what is equivalent to Ponniah's (2001) and Inmon's (2005) 'Farmer' classification of user, but is relying on the continuing support of back room staff rather than front room BI application developers.

The study found that the implementation of the DW/BI system in SAP using SAP BEx software fails to provide planning staff with BI applications that meet with all their reporting and analysis needs and has therefore led to the development of bespoke applications. These findings suggest that this may be because the planning staff were not involved at the scoping and planning stage of developing the DW/BI as advocated by Kimball *et al.* (2008).

The investigations into the third party software tools found that most of the features found in the bespoke BI application could be developed using a third party solution and that a tool is available within the SAP family of products. The level of expertise needed to develop the features ranged from easy to technical. The adoption of a third party tool could be used to

develop the reports by the BI application developer identified by Kimball *et al.* (2008) and provide the planning managers with an intuitive and flexible user interface that can be easily customised and maintained. The investigations also found that Crystal Reports provides a rich user interface that is easy to use to support most of the BI features.

16. RECOMMENDATIONS

The conclusion of the research was that a third party BI tool could be used to develop interactive reports that could support the requirements of the planning managers at Unilever, and would provide the planning managers with more flexibility and power in supporting the BI requirements of the group.

This research only looked at supporting the BI needs of the S&OP planning managers. Further study could be carried out by extending the BI requirements to all the departments and investigating whether SAP BusinessObjects' products, such as Crystal Reports, or other third-party software could support all their BI requirements.

The investigations were carried out to demonstrate the functionality of the software tools rather than demonstrating the impressive visual features that can be achieved when using the software. The SAP BusinessObject's family includes software called Excelsius which provides very powerful interactive presentation features that can be embedded into reports developed by Crystal Reports. Further investigations could be carried out into this software.

Finally, further investigations could also be carried out into the types of user interface and the delivery mechanism that are offered by third party BI tools, to find the most suitable one to support the security and access requirements to the reports.

APPENDIX I

Requirement No.	Short Name	Description	Evidence of Requirement Rolling Fcst Reports	Evidence of Requirement KPI Analysis Reports
001	Drill-down from FG	Drill down from a Forecast Group (FG) to show Forecast Unit (FU) detail based on a user selection of '12 month rolling","Current Year", or "Next Year".	Sequence1:2 click detail	
002	Drill-down to graphs	Drill down from an FU or total figure to produce graphs. Graphs to show: forecast totals for the period of analysis and a comparison of current year and previous year, and previous year -1 with previous year – 2 forecast trend per quarter forecast totals for promotional products forecast totals per month.	Sequence1:3DrillDownToGraphs	

Requirement No.	Short Name	Description	Evidence of Requirement Rolling Fcst Reports	Evidence of Requirement KPI Analysis Reports
003	Expand monthly data to show weekly data	Expand monthly to show weekly figures		Sequence1:6 Analysed Horizon Part 1 and Part 2
004	Drill-down product hierarchy to produce graphs	Drill down product hierarchy from Grand Total, Promotional Product, Forecast Group, Forecast Unit or Distribution Unit to produce graphs. Graphs to show: Visualizer – show bias and inaccuracy figures and 9 month moving average. Visualizer forecast – show forecast and actual figures; and linear forecast and linear actual. Var_Inac – show variance inaccuracy for analysis period Var_Bias – show variance bias for analysis period		Sequence1:2:KPIAnalysisDrillDown
005	Expand product hierarchy	Expand product hierarchy from Grand Total, Promotional Product, Forecast Group, Forecast Unit or Distribution Unit to show data.		Sequence1:2:KPIAnalysisDrillDown

Requirement No.	Short Name	Description	Evidence of Requirement Rolling Fcst Reports	Evidence of Requirement KPI Analysis Reports
006	Switch between showing % and absolute value	Switch between showing the percentage or the absolute value	Sequence1:5 Toggle Activate/Deactivate % View	
007	Analysis horizon	Change the months included in the analysis period between the current year, 12 months rolling or next year.	Sequence 1:7 Analysis Horizon	
008	Change background colour	Display a different background colour for negative values	Sequence 1:7 Analysis Horizon	
009	Add comments	Add comments to describe the meaning of figures	Sequence 1:7 Analysis Horizon	
010	Calculate growth per quarter	Aggregate FG figures for current quarter, current quarter - 2, -1, + 1, + 2, + 3, + 4 and compare to same period one year earlier.	Sequence 1:7 Analysis Horizon	

Requirement No.	Short Name	Description	Evidence of Requirement Rolling Fcst Reports	Evidence of Requirement KPI Analysis Reports
011	Add "Inactive" or "New" text	If FG data is nil for the previous year, show text in data cell as "New" or if data is nil for the previous two years, show text as "Inactive"	Sequence1:5 Toggle Activate/Deactivate % View	
012	Order FU's by volume	Order Forecast Units by volume.	Requirements document. Unilever S&OP ReportsV1.doc	
013	Show 3 years data	Show data for current year, year -1 and year -2.	Requirements document.Unilever S&OP ReportsV1.doc	
014	Show months by name	Show months by name and not month number.	Requirements document.Unilever S&OP ReportsV1.doc	
015	Plot different charts on one graph	Show forecast and actual figures in different formats i.e. bar chart and line chart.	Requirements document.Unilever S&OP ReportsV1.doc	
016	Show comparison of previous years on same graph	Add bars to show the differences 'yr current vs yr-1' and 'yr-1 vs yr-2'	Requirements document.Unilever S&OP ReportsV1.doc	

Requirement No.	Short Name	Description	Evidence of Requirement Rolling Fcst Reports	Evidence of Requirement KPI Analysis Reports
017	Show rolling trend lines on graphs	Show rolling trend line on Visualiser_Fcst graph		Requirements document.Unilever S&OP ReportsV1.doc
018	Change graph colour depending on forecast figures	Show over forecast figures in red in under forecast in green.		Requirements document.Unilever S&OP ReportsV1.doc
019	Ability to show next 6-12 months forecast figures on graph	Ability to show next 6-12 months forecast figures on the Visualiser_fcst graph.		Requirements document.Unilever S&OP ReportsV1.doc
020	Aggregate data to current year total	Calculate current year total from data provided by the query	Sequence 1:7 Analysis Horizon	

Requirement No.	Short Name	Description	Evidence of Requirement Rolling Fcst Reports	Evidence of Requirement KPI Analysis Reports
021	Aggregate data to 12 month rolling total	Calculate 12 month rolling forecast total based on the sum of the current month through to 12 months in the future.	Sequence 1:7 Analysis Horizon	
022	Calculate 12 month variance total as percentage	Calculate 12 month variance total based on 12 month rolling total divided by sum of previous years 12 month rolling data. Display as percentage.	Sequence 1:7 Analysis Horizon	
023	Calculate variance compared with previous years variance total as percentage	Calculate Variance vs Y-1 variance total based on current year total minus sum of previous years data divided by sum of previous years data. Display as percentage.	Sequence 1:7 Analysis Horizon	
024	Aggregate totals for Year to Date	Calculate totals from beginning of the year to date of data extraction.	Sequence1:2 click detail	

Requirement No.	Short Name	Description	Evidence of Requirement Rolling Fcst Reports	Evidence of Requirement KPI Analysis Reports
025	Aggregate Year to Go totals	Calculate totals from date of data extraction to the end of the year.	Sequence1:2 click detail	
026	Bias has same sign	Show number of weeks and number of months the bias has the same sign (+ or -)	Sequence1:6 Analysed HorizonPart2	
027	Printable	All graphs and data to be printable to take to meetings	Requirements document.	Requirements document.
028	Security	Only relevant people should have access to the reports	Requirements document.	Requirements document.
029	KPI	Show KPI's as dashboard		Conversation.
030	Show Totals	Show total in FG sheet and when drilling down from FG to FU detail	Sequence1:2 click detail	

Table 5 - Requirements list mapped onto BI application features

REFERENCES

BCS (2009) Understand all angles with BI 2.0. Retrieved October 2009 from http://www.bcs.org/server.php?show=ConWebDoc.27807

Benyon-Davies, Paul (2002) Information Systems: An Introduction to Informatics in Organisations. Palgrave

Gonzales, Michael L. (2003) IBM Data Warehousing: With IBM Business Intelligence Tools. Wiley & Sons, Inc. (US)

Hoffer, Jeffrey A.; Prescot, Mary B.; McFadden, Fred R. (2007) Modern Database Management (8th Ed.). Pearson Education.

Imhoff, Claudia, Galemmo, Nicolas, Geiger, Jonathan G. (2003) Mastering Data Warehouse Design: Relational and Dimensional Techniques. John Wiley & Sons

Imhoff, Claudia; Loftis, Lisa.; Geiger, Jonathan G. (2001) Building the Customer-centric Enterprise: Data Warehousing Techniques for Supporting Customer Relationship Management. New York John Wiley & Sons, Inc. (US)

Imhoff, Claudia; Pettit, Raymond (2004). The Critical Shift to Flexible Business Intelligence. What Every Marketer Wants – And Needs – From Technology. Intelligent Solutions Inc.

Inmon, William, H. (2005) Building the Data Warehouse. Wiley Publishing.

Kimball, Ralph; Ross, Margy (2002) The Data Warehouse Toolkit: The Complete Guide to Dimensional Modeling. John Wiley & Sons

Kimball, Ralph; Ross, Margy; Thornthwaite, Warren; Mundy, Joy; Becker, Bob. (2008) The Data Warehouse Lifecycle Toolkit. Wiley Publishing Inc.

McDonald, Kevin (2002) Mastering the SAP Business Information Warehouse. New York John Wiley & Sons, Ltd. (UK)

Mundy, Joy; Thornthwaite, Warren; Kimball Ralph. (2006) The Microsoft Data Warehouse Toolkit. Wiley Publishing, Inc., Indianapolis, Indiana

Peck, George (2003) Crystal Reports 9: The Complete Reference. New York McGraw-Hill Professional

Ponniah, Paulraj (2001) Data Warehousing Fundamentals: A Comprehensive Guide for IT Professionals. New York John Wiley & Sons, Inc. (US)

Rasmussen, Nils; Goldy, Paul S.; Solli, Per O.(2002). Financial Business Intelligence: Trends, Technology, Software Selection, and Implementation. New York John Wiley & Sons, Inc. (US).

SAP AG (2009). Exploring Your Business at the Speed of Thought. Retrieved October 2009 from https://goexplore.ondemand.com/el/ExplorerSolutionBrief.pdf

SAP Business Objects (2008). Unilever Jump-Starts Growth Strategy Using Business Objects Data Integrator. Retrieved October 2009 from http://www.sap.com/cis/partners/BO/SuccessStories/Unilever.pdf

Sowa J.F., J.A. Zachman J.A. (1992) Extending and Formalizing the Framework for Information Systems Architecture. IBM Systems Journal 31, No. 3, 590 – 616

Swoyer, Stephen (2009) Report Debunks BI Usage Myth. Retrieved October 2009 from: http://www.tdwi.org/News/display.aspx?ID=9440

Thierauf, Robert J. (2001) Effective Business Intelligence Systems. Westport, CT Quorum Books

Zachman J. A. (1987) A Framework for Information Systems Architecture. IBM Systems Journal 26, No. 3, 276 – 292